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THE RAINSTORM OF AUGUST 24-26, 1905, IN EASTERN IRELAND.

BY SIR JOHN W. MOORE, M.D., D.Sc., D.P.H., F.R.Met.Soc.

THE rainstorm which visited the East of Ireland on Thursday and Friday, August 24 and 25, 1905, was of such exceptional intensity that some more detailed account of it than has already been published may prove of interest to the Fellows of the Royal Meteorological Society.

By way of preface, it may be stated that the glorious summer of 1905 passed away with the passing of July, and that, unlike the preceding three months, August proved for the most part very unsettled, rainy, and cool. The disturbances which reached our shores from the Atlantic were numerous, but, as a rule, of no great intensity, so that they brought wet weather rather than wind-storms. In the *Monthly Weather Report* of the Meteorological Office for August it is stated that the rainfall was above the average at three-fourths of the stations in Great Britain, and at nearly every station in Ireland, the excess at some western stations being between 2 inches and 4 inches. Thunderstorms also were numerous and visited nearly all districts, being very severe in some instances and accompanied by heavy local rains.

It is especially noteworthy that the great majority of the atmospheric disturbances of the month, instead of skirting the Atlantic seaboard of Ireland and Scotland on a north-easterly course as is usual, came ashore on various parts of our south-western coasts and travelled eastwards or north-eastwards across the country. The disturbance which caused the torrential rainfall about to be described was sighted off the shores of Kerry and Cornwall on the morning of Thursday, August 24. At 8 a.m. of Friday, the 25th, it was central near the Scilly Islands, where the barometer had fallen gradually to 29·58 ins. Thence it travelled slowly northwards up St. George's Channel, its centre passing near Dublin early on the morning of Saturday, the 26th (Fig. 1). At this time the system suddenly changed its course, crossing the Channel eastwards to Wales, and

it finally passed over Central England and out to sea at the mouth of the Humber in a north-easterly direction. The lowest barometer reading in Dublin during the passage of the disturbance was 29·420 ins., in the early morning hours of the 26th.

It should be mentioned that the depression just described was preceded by a period of very unstable atmospheric equilibrium over North-western Europe, and by the passage of another disturbance across the British Isles in the interval between the 22nd and the 24th. That system had caused cold North-west winds, and, as a matter of fact, the temperature fell to 43° at Donaghadee and to 49° in Dublin in the course of Wednesday night, the 23rd. At the Normal Climatological Station in Trinity

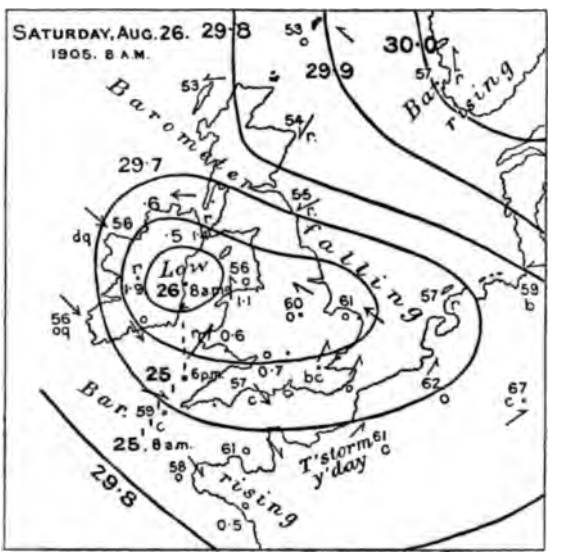

FIG. 1.—Weather Map.

College, Dublin, the shade minimum was 47°·0, the grass minimum 38°·1 on the night of the 24th.

Having said so much by way of preface, I now give my notes of the weather, beginning with 9 a.m. of Wednesday, August 23, as furnished to the Dublin *Daily Express* newspaper.

Wednesday, August 23—9 a.m.—The barometer is recovering steadily from yesterday's depression. A cool North-west wind is blowing, and the weather is fine and dry. The amount of cloud is increasing, but appearances are more favourable.

9 p.m.—The weather held up well to-day, only a few drops of rain falling in Dublin. The sky was chiefly cloudy. In the afternoon the rise of the barometer was checked.

Thursday, August 24—9 a.m.—The barometer is falling slowly, but so far no break in the weather has occurred. It has been a quiet, fine, bright morning. A light Easterly under current has set in along the coast.

9 p.m.—To-day was very fine. There was a good deal of sunshine, but in the afternoon a veil of cirrus spread over the sky producing a solar halo at 2 p.m., but afterwards blotting out the sunshine.

Friday, August 25—9 a.m.—A well-defined cyclonic system of no great energy is central to the south-eastward of Dublin. The barometer is falling slowly. The disturbance has been accompanied by heavy rain and a moderate to fresh North-east wind on the east coast of Ireland. The rainfall to the present amounts to ·513 in. in Dublin and to ·682 in. at Greystones, Co. Wicklow. Temperature is low and the air is very damp.

9 p.m.—A pitiless and incessant rain fell throughout the day, which was dark, gloomy, and cold. By 5 p.m. the rainfall had reached ·966 in. since 9 a.m., and it now much exceeds an inch. The depression is apparently travelling very slowly, while it gathers energy as it goes. The highest temperature in the daytime was 55°·9.

Saturday, August 26—9 a.m.—The barometer is rising as the rainstorm depression moves off to the northward. The reading was 29·420 ins. in the early morning hours. Temperature continues low for the time of year. But it is round the rainstorm of yesterday that the interest of this morning's report mainly centres. The rainfall of the past 36 hours in the south-east of Dublin equals 3·949 ins., and of that large quantity 3·436 ins. have fallen within the past 24 hours. The corresponding figures of rainfall at Greystones, Co. Wicklow, are 4·170 ins. and 3·350 ins. respectively. In Trinity College 3·300 ins. were registered this morning, and ·489 in. at 9 a.m. yesterday. At Leeson Park the measurements were ·590 in. and 3·740 ins. respectively. At Kingstown ·520 in. and 3·15 ins. fell at the People's Park, and ·520 in. and 3·17 ins. at the Board of Works Observatory. At Cloneevin, Killiney, the measurements on the two days were ·580 in. and 3·060 ins. ; at Fassaroe, near Bray, ·640 in. was measured at 9 a.m. on the 25th, while 4·450 ins. was the phenomenal measurement at 9 a.m. to-day.

9 p.m.—To-day was fine till 5 p.m., when the sky became overcast and showers fell.

Sunday, August 27—9 a.m.—The cyclonic system, which caused the disastrous rainstorm of Friday, has apparently changed its course and is passing off in a north-easterly or easterly direction. A brisk North-west wind is blowing this morning, but the sky is densely clouded. The rainfall of the past week at this station (Dublin City) amounts to 4·107 ins. on six days. That for the month of August so far equals 6·108 ins. on 18 out of 26 days. This excessive precipitation has almost wiped out the deficit in the rainfall of 1905 in Dublin.

9 p.m.—The weather improved as the day advanced, becoming brighter and warmer. After midday, however, the barometer began to fall, and towards evening the sky once more assumed an unsettled aspect.

When the nimbus cleared off on Saturday morning, it was travelling from East and North-east, and consisted of a dense cirriform stratum at a great elevation, under which immense masses of cumulus were piled up.

In the *Dublin Journal of Medical Science*, October, 1905, I published the following "remarks" on the weather :—

August, 1905, may be described as a changeable, cool, and rainy month. It will be especially memorable for the record-breaking rainstorm which visited the east coast of Ireland, and in particular the Counties Dublin and Wicklow, on Friday, the 25th. In Dublin this remarkable rainstorm began shortly after 9 p.m. of the 24th and persisted for 34 hours, the resulting measurement in the rain-gauge being 3·949 ins. at Fitzwilliam Square, 3·789 ins. in Trinity College, 4·330 ins. at Leeson Park, 3·990 ins. at Glasnevin Royal Botanic Gardens, and 3·725 ins. at the Ordnance Survey Office, Phœnix Park. The following table of the rainfall measurements taken at 9 a.m. of Saturday, the 26th, for the

previous 24 hours, may be looked on as historic from a meteorological point of view :—

	ins.
Dublin: Trinity College	3·300
,, Fitzwilliam Square	3·436
,, Leeson Park	3·740
,, Leinster Road, Rathmines	3·459
,, Royal Botanic Gardens, Glasnevin	3·580
,, Ordnance Survey Office, Phœnix Park	3·350
Kingstown: The Park Observatory	3·150
,, Board of Works Observatory	3·170
Killiney: Cloneeven	3·060
Stillorgan: White Cross	3·220
Dundrum: Lynton	4·040
Bray: Fassaroe	4·450
,, Rocky Valley, Great Sugar Loaf	5·500
Greystones: Knockdolian	3·350
Newcastle, Royal National Hospital	4·110
Malahide: The Green	3·110
Ardgillan: Balbriggan	3·120

From this list it would appear that the rainfall entered to the 25th exceeded 3 ins. at all stations in the Counties Dublin and Wicklow, while it rose above 4 and even 5 inches at stations situated near the Dublin and Wicklow Mountains. It is worth noting that the wind was Easterly and North-easterly during the downpour—that is, on shore along the coast-line of the drenched counties.

I venture to submit that the remarkable downpour evidenced by the figures given above (Fig. 2) was brought about by the co-operation of several factors. First, a chill antecedent to the arrival of the rain-bearing depression; secondly, the slow progress of this depression; thirdly, the fact that the Counties Wicklow and Dublin lay to the westward of the cyclonic centre and so got its North-easterly and Northerly winds; fourthly, and lastly, the physical configuration of those counties and their coast-line.

To the last point especial attention should be drawn. Along the shores of the Co. Wicklow the land rises from the coast somewhat abruptly at a distance of one or two miles from the sea. Wicklow Head and Bray Head are headlands of considerable extent and height—the latter is precipitous and towers to 790 ft. To the westward lie the Wicklow Mountains, which run north and south through the middle of the county and culminate in the ridge of Lugnaquilla at a height of 3039 ft. above sea-level. The southern coast of the Co. Dublin is indented by two beautiful bays—Killiney Bay and Dublin Bay. These are separated from each other by the range of the Killiney Hills, 480 ft. The bold headland of Howth (Ben Edar, 563 ft.) forms the northern boundary of Dublin Bay. North of Howth the coast is flatter and there are estuaries at Malahide and between the villages of Donabate and Lusk. At the extreme northern end of the county the ground rises from Skerries and Balbriggan on the coast into undulating hills from 100 to 250 ft. in height. The prevailing character of the subsoil rock is calp, limestone, and granite. South of Dublin the Dublin Mountains rise tier after tier, with intervening valleys to the summit level of 2374 ft. in Kippure—a mountain from which three rivers flow: the Liffey, the Dodder, and the Glencree.

From the foregoing it will be seen that Easterly and North-easterly

winds blowing in upon the shores of Dublin and Wicklow would be deflected upwards by the highlands. If such winds were heavily charged with moisture (as they necessarily would be when forming part of a cyclonic system of Atlantic origin and travelling northwards up St. George's Channel), rapid condensation would occur and heavy rains result. This has frequently happened, and in the second volume of *Climates and Baths of Great Britain and Ireland*, published by the Royal Medical and Chirurgical Society, I allude to this very point in the following sentences (p. 395):—

"A few miles south of the city [of Dublin] lies a range of mountains, with summits varying in height from 1000 to more than 2500 ft.

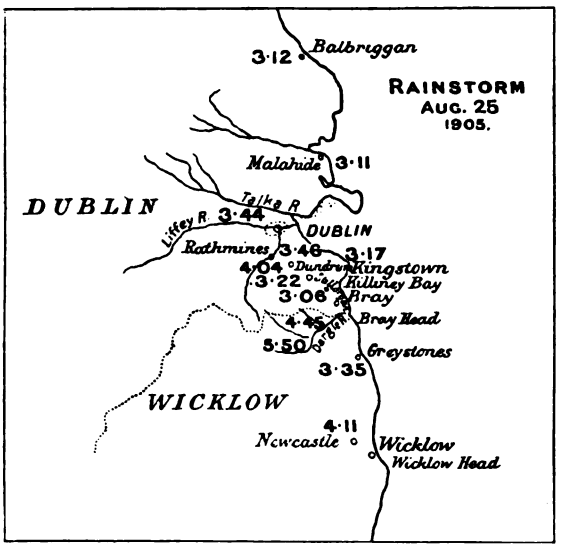

FIG. 2.—Rainfall.

This mountain chain intercepts the vapour-laden winds at all points between south-south-east and south-west, and so the rainfall is diminished and the sky is comparatively cleared during the continuance of the Southerly and South-westerly winds, which so frequently prevail. The absence of any very high ground to the northward of the city—with the exception of the Hill of Howth, which rises, however, only to 563 ft. —also prevents excessive precipitation with South-west winds. It is true that with Easterly (South-east to North-east or North) winds the precipitation (often in the form of hail, and in winter of sleet or snow) in and about Dublin exceeds that which occurs at such a time inland or on the Atlantic coasts. Were it not for this 'lee-shore' condensation the Dublin rainfall would be considerably smaller even than it is."

Turning from the causes to the effects of the remarkable rainstorm of August 24 and 25, 1905, we find that a destructive flood swept over the low-lying parts of the Bray Urban District near the mouth of Bray River, or as it was more poetically called by Sir William Petty in the seventeenth century the "Bray Water." This short-coursed and rapid river is formed by the confluence of three mountain-streams, which flow

eastwards from the steep slopes of the Dublin and Wicklow range. The largest of these is the Dargle River, so named from a beautiful forest glen through which it flows. It rises at a height of some 1500 ft. in a highland moor lying between Tonduff South (2107 ft.) and Djouce (2384 ft.). Thence it descends in a series of cascades to the edge of a precipice about 300 ft. high, where it becomes the well-known and picturesque Powerscourt Waterfall. Two miles further on the Glencree River joins it, coming from the north-eastern face of Kippure (2473 ft.), and draining the Tonduff Mountains, north and south. The next tributary of importance is the Killough River from Slieve Cullen (Great Sugar Loaf) and Calry Moor, a district in which 5·5 ins. of rain was measured by Prof. W. F. Barrett as the product of 24 hours' downpour ending 9 a.m. of Saturday, August 26. Emerging from the Dargle, the river receives the Glencullen water one mile and a half east of Enniskerry, a charming village built on the southern slope of a deep mountain valley. The united streams flow as the "Bray Water" to reach the sea at the town of Bray 2½ miles to the eastward.

The heavy and continuous downpour of rain in the mountainous watershed of the streams just traced from their sources to the sea produced an unpredecented freshet late on the evening of Friday, August 25. Between Enniskerry and the confluence with the Dargle River, the Glencree River wrought terrible damage. It undermined and swept away large tracks of the public road running along its southern bank, destroyed three bridges, endangered the bridge which carried the Vartry supply pipes of the Dublin district across its bed, and scooped out its own channel in the most surprising way, exposing large rounded boulders of granite and limestone. Even large trees were uprooted by the rushing torrent, and these, swept into the current, added to the destruction by blocking the channel. A like flood tore down the Dargle River, the rocky banks of which were stripped of their covering of shrubs, herbage, ferns, and moss. A mile above Bray the raging torrent broke down a retaining wall, poured out on the main road, tearing it up and covering it with shingle, and finally flooded the entire valley. A weir, the object of which was to divert a large mill-stream from the river, was destroyed, and the swollen river finally poured in a cataract a third of a mile in length over a turf-covered bank into the People's Park, and excavated a trench in the gravel which was in places six feet deep. The greater part of "Little Bray" is built on a common in the valley next the People's Park, and the water rose to a height of 4 feet in the streets, flooding the houses, destroying domestic animals and fowls, wrecking furniture, and covering floors, yards, and gardens with a thick alluvial deposit. Providentially the flood came comparatively early in the night, else serious loss of human life would have been inevitable. As it was, only one man was drowned. To add to the difficulty of rescue by boats, etc., all the electric lamps in Bray went out about 10 p.m., the engine-fires in the electrical generating-house having been put out by the flood-waters. Next morning the surface of the sea of Bray was seen to be thickly studded with floating articles of furniture, barrels, and trees, which had been carried out to sea by the resistless flood.

Mr. Richard M. Barrington, LL.D., J.P., of Fassaroe, 2 miles inland from Bray, sent me bulletins of the rainstorm while it was in

progress. These will doubtless be of interest. At 8.20 p.m. of August 25 he wrote as follows:—

In gauge at 9 a.m. this day ·640 in. This was let out.

In gauge at 4.15 p.m. this day ·800 in. This was *not* let out.

In gauge *now* (8.20 p.m.) 2·790 ins. (including ·800 in. as above). Raining hard. I expect a record fall for 24 hours at 9 a.m. to-morrow. R. M. B.

Then, on August 26, Mr. Barrington wrote:—

In gauge, 9 a.m., 25th, ·640 in.

In gauge, 9 a.m., 26th, 4·450 ins.—total fall in the storm, 5·090 ins. All of the 4·450 ins. fell before 1 a.m. on the 26th, or in 16 hours, and 3·080 ins. fell in six hours, 4.20 p.m. to 10.20 p.m. I have suffered damage to about £1000. R. M. B.

In conclusion, I may state that never before had I registered a rainfall of 3 ins. in 24 hours in Dublin, and my records extend back 40 years without interruption. On eight previous occasions only since 1865 have 2 ins. or upwards of rain been measured in Dublin at 9 a.m. as the product of the preceding 24 hours' precipitation. The previous excessive falls were—

	ins.		ins.
1874. August 13 . . .	2·482	1899. August 5 . . .	2·227
1880. October 27 . . .	2·736	1900. August 2 . . .	2·135
1892. May 28	2·056	1901. November 11 . .	2·037
1896. July 24	2·020	1902. September 2 . . .	2·037

DISCUSSION.

Dr. H. R. Mill said that as a result of discussing heavy cyclonic rains, he had found they occurred nine times out of ten on the left of the track of the depression, and this instance was a confirmation of the rule. He thought that the heavy rain was not due mainly to the configuration of the district, but rather was the result of causes in the atmosphere, which would have produced a heavy fall over a plain or on hill slopes. He would be inclined to extend Mr. Barrington's law that one-tenth of the annual rainfall may be recorded in any one day, falling back on Mr. Symon's old dictum that a fall of 4 inches in twenty-four hours may occur at any place in the British Isles. At Seathwaite the heaviest fall of rain in one day was 8·03 ins. on November 12, 1897, and falls exceeding 5 inches were recorded almost every year. It was very desirable to have as close a network of rain-gauges as possible all over the country, for stations half-a-mile apart or less might define the boundary of a heavy fall and be extremely helpful in the elucidation of such phenomena as the one under discussion. The Society had to congratulate itself on Sir John Moore's prompt investigation of this remarkable storm, as when some months elapsed before such an occurrence was looked into, the facts were apt to be partially forgotten and unconsciously exaggerated.

Dr. R. H. Scott remarked that he had visited the district affected by the rainstorm soon after the disaster, and could testify as to the damage done. It was a remarkable fact that the two maximum falls of rain of 4 and 5½ inches occurred on the sea slope of the hills, over the ridge facing the sea, at about a distance of 3 or 4 miles from the sea. The fall at Newcastle was also on the sea side of the hill slope. Mr. R. M. Barrington appeared to be the greatest sufferer, two bridges on his estate being carried away, and the main water-supply to Dublin being in great peril. Close down by the sea the flood of water was so great that it scooped out great holes in the level ground 6 or 7 feet deep.

Mr. F. GASTER said that he had looked up the charts for the dates of the depressions accompanying the rainstorm, and ageeed with Dr. Mill that a further explanation of the phenomena than that given by Sir John Moore was required. It was a very curious thing that the maximum falls should occur on the low-level ground near Dublin and not among the hills, as was usually expected. He would like to remark that what was usually considered a dry wind should be so frequently accompanied with such torrential rain. Recently Mr. Rollo Russell, in a paper before the Society, had shown how the mingling of different air currents often produced these abnormal falls of rain, and, in his opinion, the present instance was the dry, cold East wind meeting the previously-existing moist South-west or South wind, and bursting in under the upper moist current from the South-west, had caused rapid condensation and the rain to come down through the Easterly surface wind. He had often noticed that cirrus and alto-cumulus clouds, coming from the South and South-west when the wind was in an Easterly direction, proved a good forecast that the next day would be wet. In the wet year of 1903, he had constantly noticed that depressions coming up the English Channel with a South-westerly upper current, meeting a North-easterly wind, would be accompanied by the very heavy rain experienced in the South of our island during that year.

Mr. F. J. BRODIE said that if it was expected to find a complete explanation of every extraordinary phenomenon that occurred we were doomed to disappointment. The heavy rainstorm came with the East wind, but the moisture was brought from the west and south-west. The depression that brought the storm was a slow-moving one coming in a south-easterly direction from the Cornish coast, but all the time a warm moist current was flowing steadily from the Bay of Biscay. The warm current brought the moisture with it, and, meeting with the cooler North-easterly wind, condensation was caused. He agreed with Dr. Mill that it was possible to have 3 or 4 inches of rain in any part of the country, and although every endeavour should be made to find out the cause of these extraordinary rainstorms, yet we must be cautious not to accept any one particular theory as an explanation of the occurrence. It was remarkable that the neighbourhood of Dublin seemed peculiarly liable to heavy falls of rain, for although the average rainfall differed very little from that of London, yet during the last thirty years there were no less than eight occasions of amounts of 2 inches and upwards in the course of twenty-four hours. In London, using the Brixton figures, there was not one fall of 2 inches during the same period. It was all the more remarkable as Dublin was in the driest part of Ireland.

Commander M. W. C. HEPWORTH said that in studying rainfall it was well to consider the conditions under which rain fell in other parts of the world than our own. In this part of the world—he might say in north-western Europe—steady rain was usually experienced in front of the trough of depressions; but in other parts, in the southern hemisphere—on the east coasts of the large continents—the weather was usually bright and sunny in front of an approaching depression and the rainfall occurred in rear of it. He had mentioned this fact to the Society as far back as 1882 or 1883. Take Australia, for example: a depression first coming into contact with the land on the west coast, some rain was deposited; the depression might then pass right across the continent without giving any rain, but on its arrival on the other side—the eastern seaboard—the equatorial wind in front of it took up moisture, which was precipitated when the wind changed to a polar quarter, to Southward or South-westward, in rear of it. From Sandy Cape in Queensland to Gabo in Victoria, from Cape Corrientes in Africa to Cape Agulhas, and from the Brazils to Cape Virgins, the bright genial weather was usually associated with a falling barometer in front of a low pressure system and persistent rain in rear of it.

Mr. W. MARRIOTT said that there were many other instances of somewhat

similar heavy rainfall, which took place usually during the occurrence of a shallow or slow-moving depression. Two such instances occurred in June of the present year, when nearly 2 inches of rain was recorded at Dungeness on the 5th and 29th of that month. He would like to emphasize what Dr. Mill had said of the probability of there being a rainfall of 4 or 5 inches in one day at any station. It was therefore very necessary that observers should see that their rain-gauges were in good condition, and also of sufficient capacity to hold such an amount. The greatest fall at Seathwaite in one day had been 8·03 ins. on November 12, 1897. At Scarborough, however, on August 6, 1857, the observer had measured 9½ inches, but the rainfall actually exceeded that amount, as the gauge had overflowed. He (Mr. Marriott) considered that the records from self-recording rain-gauges would be of extreme value in heavy rainstorms, as by that means information would be secured as to the rate at which the rain fell. It was possible, however, that in some forms of recording rain-gauges the precipitation might be so rapid as not to permit the proper emptying of the bucket or siphon, and so a correct record would not be obtainable. He showed a slide illustrating Mr. J. H. W. Biggs' "Rain-timer," which had been used at Bowness, Windermere. The rain was collected in an ordinary 5-inch funnel and passed into a wire-gauze cup (something like a tea-strainer), which was suspended on the arm of a balance. When rain fell, the cup was pressed down and the long arm of the balance moved a connection with a clock which was thus set going. When the rain ceased the cup rose, and by releasing the arm the clock was stopped. The clock, therefore, showed the duration of the rainfall.

Mr. BALDWIN LATHAM suggested that all stations should have self-recording rain-gauges. It would then be possible to tell exactly at what rate the rain had fallen. In his own garden at Croydon he had had in use a self-recording gauge since 1879, which had worked without a break since that year. It was true it needed careful attention, especially in heavy continuous rains, as it would only hold an amount of 1½ ins. He also had other self-recording rain-gauges in use, but he found none acted so well as the tipping-bucket pattern, the other forms of siphon gauges generally failing with a heavy fall, when they were especially needed to work well. The rate of fall of rain was much greater than most people imagined. Nine inches in twenty-four hours was spoken of as a very large fall, but it was nothing in comparison to a fall at the rate of 36 inches. Fortunately rain falling at such an extremely rapid rate did not last long, or the mischief done would be very great. Only the other day great damage was reported from the Midland districts, but the mischief was caused by very heavy rain falling in about a quarter of an hour. He hoped the Fellows present would see the necessity of getting self-recording instruments, and would use their influence in having them established in all parts of the country.

Mr. W. B. TRIPP, as an instance of very heavy rainfall, referred to the summer drought in South Africa usually breaking up with heavy rain which, flooding the river, removed the sand bar which had gathered at the mouth of the harbour at East London. This occurred regularly till about 30 years ago, since when it had entirely failed till the present year, when on October 9-11 about 11½ ins. of rain had fallen, mostly occurring in twenty-four hours on the 11th, and the obstruction had been removed again. He thought this remarkable after a lapse of over 30 years.

Mr. J. HOPKINSON suggested that the heavy rain with an East wind might be caused by the cool current from the East meeting a higher South-west current laden with moisture, and by reducing the temperature of this vapour to below the point of saturation, causing it to fall as rain, rather than by the East wind itself bringing rain-clouds.

The PRESIDENT (Mr. R. BENTLEY) said that the thanks of the Society were

due to Sir John Moore for his paper and the discussion that it had caused. It was fortunate that Sir John Moore was on the spot to make these investigations, as records of exceptional falls were of special value, although all deplored the damage that was sustained through the disaster.

[Mr. RICHARD HASSARD, in a Note to the Secretary, said :—

"The township of Rathmines and Rathgar, a suburb of Dublin, with a population of about 33,000, is supplied with water from works constructed in the Glenasmoel Valley, distant in a south-westerly direction about 7½ miles from the centre of Dublin.

"The rain gauge situate between the two reservoirs in which the following amounts of rain were registered is at an altitude of 516 ft. above the Ord. Datum, and the drainage area above it attains to an extreme height of 2473 ft.

"The area draining to the reservoirs is about 6700 acres, with very steep slopes of silurian and granitic formation, and the rain fell as follows :—

"August	24th,	from	8.30	p.m.	to	9.0	a.m. (on 25th)	·52 ins.
,,	25th,	,,	9.0	a.m.	,,	3.0	p.m. ,,	·72 ,,
,,	,,	,,	3.0	p.m.	,,	9.0	p.m. ,,	2·88 ,,
,,	,,	,,	9.0	p.m.	,,	12.0	p.m. (midnight)	2·02 ,,
,,	,,	,,	12.0	p.m.	,,	9.0	a.m. (on 26th)	·09 ,,

"The above gives 6·14 ins. in 27½ hours.
or 5·62 ,, 15 ,,
or 4.90 ,, 9 ,,
or 2·02 ,, 3 ,,

but as is known by comparisons made with a gauge formerly kept in the drainage area at an altitude of 800 ft., the rain over the whole area must have been considerably more than above given, and probably was not less than 8 or 9 ins. in the 27½ hours that the storm lasted, and this is corroborated by the discharge over the waste weir of the lower reservoir, 200 ft. in length, over which the water attained a depth of 4 ft. at the height of the flood, and in addition there were two pipes of 27 and 24 ins. respectively in diameter discharging water from the reservoir as well.

"Under these circumstances there could not have been less, at that moment, than about 270,000 cubic feet of water per minute flowing off the 6700 acres, or about 40 cubic feet of water per acre per minute."]

The French Antarctic Expedition.

Dr. Jean Charcot contributes a paper to the *Geographical Journal* for November 1905 on the French Antarctic Expedition. He says :—

"Of meteorological studies, which were carefully conducted, the chief results are—low summer temperatures, great and sudden thermometric changes, frequent North-east and East-north-east squalls, with thermometer high and barometer low ; fair weather with gentle South-south-west breezes, with low thermometer and high barometer (mean about 30 inches). Lastly, in fine weather, very great regularity in the diurnal variation of the hygrometric conditions, a variation identical with that observed at Cape Horn.

"Polar auroras very rare and faint.

"It is interesting to compare the simultaneous character of our meteorological records with those of Año Nuevo and of the Observatory established at the South Orkneys."

THE AQUAMETER.

By WILLIAM B. NEWTON, Ph.D., F.C.S., F.I.C.

[Read November 15, 1905.]

THE amount of humidity in the atmosphere is of such great importance in the study of meteorology that it has long demanded a better method of determining it than we have hitherto used.

To ascertain the exact percentage of aqueous vapour in the air has hitherto required a somewhat cumbrous chemical apparatus and careful weighing by delicate balance.

It is true that the dry-bulb and wet-bulb thermometers and the hair hygrometer similar to de Saussure's instrument are largely used for obtaining an indication of the moisture of the air; but no one who has tried them scientifically would call them accurate instruments, and they would never have had their extensive use had a better apparatus been available.

But because of the extensive use of the dry and wet bulbs, and because they are a statutory instrument used by H.M. Government, they cannot be condemned without a few words of discussion.

Let us recall to our recollection the principle of the dry-bulb and wet-bulb thermometers. It is this —given a wet surface exposed to the air, the water will evaporate from it rapidly if the air is devoid of moisture and not at all if the air is saturated with moisture.

The Aquameter.

Between the points of absolute dryness and of absolute saturation the rapidity of evaporation from a wet surface is proportional to the dryness of the air. This may sound a little complicated, but the fact is obvious that dry air absorbs more moisture than humid air. The liquid water in turning into aqueous vapour requires to absorb the latent heat necessary to evaporate, just the same as water at its boiling point absorbs a large amount of latent heat without rising in temperature as it changes into steam. Consequently, if of two thermometers the bulb of one is wet and the other dry, the dry one registers the temperature of the air, the wet one the temperature of the air less an amount of heat absorbed by the water which has passed from the liquid state into that of aqueous vapour.

Here, however, arises the source of error in the dry and wet bulb; the amount of water converted into aqueous vapour, and, consequently, the amount of heat drawn from the wet bulb, depends at least as much on the rate at which the air is passing over the thermometers as upon the dryness of the air. If the air is almost stagnant there will be little difference between the dry and wet bulb; on the other hand, with a strong current even nearly saturated air will produce

a considerable evaporation, and by the difference of the readings appear to be quite a dry air. There are other smaller sources of error which arise in taking the difference of readings between the dry and wet bulb as the measure of the humidity of the atmosphere, and there can be little doubt this antiquated instrument would have been abandoned long ago if it had been tested constantly against accurate measurements.

The hair hygrometers, dating back to the time of their origin with Guy Lussac and de Saussure, are not instruments to inspire great confidence. The expansion and contraction of hair under various degrees of humidity would vary with the head it comes from, and would require a small scientific research for each instrument standardised before one could trust the readings on its dial. The interference of time and temperature would affect its standardisation. Before using a hair hygrometer for any important work it would be necessary either to standardise it oneself or have the guarantee of some skilled scientist. I do not know if Kew certificates would be granted for this class of instrument.

To turn to more accurate methods for determining the aqueous vapour, the chemical methods are complicated, and even the simplest necessitate a bulky measurement of air and absorption tubes of sulphuric acid and pumice stone, which, as before mentioned, need to be carefully weighed on a delicate chemical balance, giving an amount of work and trouble that can hardly be asked as a daily task from the most scientific meteorologist.

Having been through the troubles of trying to find a quick method of determining exactly the amount of moisture in the air, I suggest the use of this instrument which I have called the "Aquameter."

The instrument consists simply of a mercury reservoir connected by a rubber tube to a measured glass tube with two taps. While the top tap is open, by raising the reservoir the mercury is put up to the mark 100. On lowering the reservoir till the mercury in the measured tube drops to mark 0, 100 measures of air are drawn in (in the case of the present instrument 100 cubic centimetres). The top tap is then closed.

The tap in the side tube at the top of the measuring vessel is then opened, connecting a small glass bulb containing phosphoric anhydride. This absorbs the aqueous vapour of the 100 measures of air. On then getting the mercury in the reservoir and that in the measured tube at the same level (thus giving the air in the measured tube the atmospheric pressure it came in at) the rise of the mercury above 0 in the measured tube is the exact percentage by volume of the aqueous vapour previously in the air. With an additional tap and bulb containing solid caustic potash the carbonic acid gas in the air can also be determined in the same manner, the additional reading of the scale to that shown after the aqueous vapour is absorbed gives the carbonic acid in parts per ten thousand.

Before commencing the experiment the top tap is closed, and the taps to the two bulbs are opened in order to remove the aqueous vapour and carbonic acid in the air of the vessel above mark 100.

To cause rapid absorption of the aqueous vapour during the experiment, the reservoir of mercury is raised so as to press as much air as possible into the absorbing flask containing the porous granular phosphoric anhydride.

The absorption then takes place in about five minutes, but it is safer

to give the instrument ten minutes so as to be certain of complete absorption before taking the reading.

As the time taken by the experiment is short, there is no need to make allowance for change of temperature. Practically there is no change of temperature in so short a time, unless the position of the instrument is moved.

The indicator for showing when the surfaces of the two columns of mercury are level is a horizontal brass bar, which is moved up or down close to the mercury tubes. This horizontal bar slides on two brass uprights.

When the saturation point is passed, for instance in misty weather, the instrument does not register the total moisture. It does not measure any moisture existing as liquid drops, but it records accurately at all atmospheric temperatures as long as the moisture in the air exists as aqueous vapour.

DISCUSSION.

Mr. D. A. Louis (who read the paper in the absence of Dr. Newton) pointed out the extreme delicacy and simplicity of the apparatus. The only operations required were moving the mercury reservoir up and down and turning a couple of taps, and by these easy means a definite quantity of air could be admitted and measured, the moisture removed and the quantity gauged to within less than one ten-thousandth of the volume of air admitted. It was this capacity for accuracy which rendered it far more suitable for solving meteorological problems than the dry-bulb and wet-bulb thermometers or the hair hygrometers usually employed. It seemed to him that the explanation of the occurrence of such a storm as that referred to in Sir J. W. Moore's paper, about which there appeared to be some difference of opinion, might be considerably elucidated by the use of an apparatus like the Aquameter, for if supplemented by the ordinary thermometric and barometric observations, the exact degree of saturation of the atmosphere could be ascertained in all the different areas concerned, and the result of the meeting of these atmospheres variously saturated and varying in temperature could be predicted. For after all it was not the quantity of moisture in the air that determined precipitation, but the degree of saturation and temperature. An atmosphere of a low degree of saturation for instance could stand considerably more ill-treatment from cold and dampness without discharging its moisture than a more highly saturated atmosphere could do, and a method capable of great accuracy was required to ascertain this point. To demonstrate this the speaker put figures before the meeting, showing that a very small amount of water may cause saturation at one temperature whilst the same quantity of water would only cause partial saturation at a higher temperature.

Dr. W. N. Shaw called attention to the want of details in the description of the instrument, which would be required to show that, under the conditions indicated, the absorption of the vapour was complete and that there was no necessity to protect the apparatus against changes of temperature.

Mr. F. Gaster suggested that if the instrument was intended for indoor observations only, it would show no indication of what was taking place outside. During ten minutes in outside air many things might happen, and he had known the temperature at Kew to fall 15° in five minutes and to rise again during the next ten minutes.

Mr. D. A. Louis, in reply to the discussion, remarked that he had not overlooked the influence of temperature when making readings with the apparatus; the thermometer as well as the barometer could be read, and if any variations were observed the well-known corrections could be made, it being merely a question of simple addition or subtraction as the case might be. The apparatus did not strike him as being suited for outside use, but he could see no difficulty in employing a clean pipe to bring the air from the outside, taking the precaution of having the ends of the pipe closed by stoppers when not in use and aspirating a sufficient quantity of air through the pipe before drawing the test quantity into the apparatus, thus ensuring a sample that would not be fouled; or the sample might be collected in suitable bottles and brought to the apparatus. With regard to leakage, firstly before using the apparatus it would be examined to see it was in order, and it would only be necessary to lower the reservoir when any leakage could be promptly detected and easily remedied. Anyway the greatest pressure it would be put under during an experiment was only about 6 or 7 inches. With regard to putting warm saturated air into the cold apparatus; with thermometers about, the observer would see that the apparatus was not used until it had attained a working temperature.

Balloon and Kite Work at Berlin.

A Reuter's message states that the Berlin Meteorological Observatory, which the Emperor recently opened in the presence of the Prince of Monaco, is fitted with all the latest appliances for meteorological research. The Emperor attaches great importance to the use of balloons in meteorology, so that an extensive balloon hall has been included in the building plan of the new observatory at Lindenburg, near Berlin. On the highest point of the plateau on which the observatory stands, is a shed which can be turned to any point of the compass, and contains a cable drum driven by a small electric motor for hauling in kites, which are to be extensively used for meteorological purposes. Electric search-lights have also been installed for night observation.

Another interesting feature of the new institute is the kite factory, where large kites, fitted with self-registering instruments, are made. The institute has its own establishment where balloons can be filled, and it is the present intention of the directors to make observations with balloons every first Thursday in the month.—*Nature*, October 26, 1905.

Egyptian Meteorological Reports.

I have the honour to inform you that the following changes will be made in the publication of the meteorological observations of Egypt and the Sudan, commencing January 1906:—

1. The daily observations made at climatological stations will no longer be published monthly, but will be included in the Annual Report.

2. The Monthly Weather Summary will be enlarged, and will include additional stations so as to connect the Egyptian and Sudan area with those of India and Europe, and will give a detailed summary of the climate of the month, together with the mean and extreme values of the principal meteorological phenomena.

3. The Annual Meteorological Report will include:—

(*a*) An account of the climate of the year in Egypt and the Sudan;
(*b*) The hourly observations made at the Helwan Observatory;
(*c*) The daily observations made at the climatological stations;
(*d*) The measurements of rainfall and the river-gauge readings of the Nile.—H. G. Lyons, Director-General, Survey Department, Cairo, Egypt, December 31, 1905.

AN ATTEMPT TO FLY KITES FOR METEOROLOGICAL PURPOSES FROM THE MISSION SHIP ATTACHED TO A DEEP-SEA FISHING FLEET IN THE NORTH SEA.

By GEORGE C. SIMPSON, M.Sc., F.R.Met.Soc.

[Read December 20, 1905.]

The Mission Ship so kindly offered for the use of the Royal Meteorological Society by the Royal National Mission to Deep-Sea Fishermen was the *Queen Alexandra*, attached to the Red-Cross Fleet. This boat is slightly larger than the ordinary trawler, so that she may, besides doing the ordinary work of trawling, carry a doctor and one or two missioners engaged in the work of the Society.

The work with which I was entrusted was to find out if it is practicable to use this boat for kite work without interfering with her ordinary fishing and mission work; and to see if the doctor would care to continue the work, and if so, to instruct him in the use of the instruments and apparatus.

My experience has led me to the conclusion that kite-flying from a trawler engaged in its ordinary work is quite possible; but that the difficulties are so great that it is not worth while for the Society to go to any great expense in this direction.

I will give an account of the conditions under which the kite work has to be undertaken and the difficulties experienced in the work. In the first place I may say that I found, as Mr. Dines has pointed out before, it is quite impossible for one man to manage a kite ascent. As the doctor did not appear to be interested in the work, help was very readily given by Skipper Farman himself and the chief engineer Mr. Hann; and the other members of the crew did all in their power to help with the kites. But although they were very willing to help and took great interest in the work, yet it was only at considerable inconvenience to themselves; for no more men are carried on a trawler than those actually necessary to work it. Thus when I was receiving help from the Skipper or any other member of the crew they were giving up their "watch below" for my benefit. Naturally one would not care to continue such a one-sided arrangement for an indefinite time.

Life on board a trawler is of course subject to great regularity, and each day's proceedings are according to a definite plan. The fleet consists of between 40 and 50 vessels under the charge of an "Admiral." The Admiral chooses each day the fishing ground and sends to it the "mark-boat," which anchors and flies definite flags. To this boat all trawlers must return each morning in order to meet the cutter, which collects the day's catch from each of the boats and then steams straight off to the market at Billingsgate. The skippers are at liberty to go where they wish to fish consistent with returning to the mark-boat in time to load the catch on the cutter.

Fishing with trawls is somewhat complicated. When fishing is to commence the trawls must first be "shot." To do this the nets and apparatus connected with them are put overboard and then the trawler

goes full steam ahead, the hawsers being paid out all the time. When sufficient length of hawser is out the speed of the boat is reduced to $2\frac{1}{2}$ miles an hour. This velocity must be kept constant all the time the nets are down: if the boat goes faster the nets are lifted off the bottom of the sea, and if the boat goes slower or stops the nets do not remain open. After fishing has proceeded for a definite time the nets are hauled. For this process the boat must be stopped and brought broadside to the waves. It will be seen from this that kite-flying is impossible when the trawls are being shot or hauled, for then the boat must be handled with regard to the trawl alone. It would be dangerous to have a kite up, when not only must the course of the boat be changed, but within a few minutes the boat must first be stopped for hauling and then put full speed ahead for shooting.

The following is the regular time-table observed on board a trawler:—

7.30 a.m.—Nets hauled after night fishing.

7.30 to 11 a.m.—The trawler joins the others assembled near the "mark-boat." The whole fleet is then very near together and small boats are continually visiting the cutter and Mission Ship. During this time the skipper and doctor are busy.

First haul, 11 a.m.—Trawls shot. This necessitates full steam ahead for a few minutes.

11 a.m. to 4.45 p.m.—Fishing proceeds; the velocity of the boat being kept at about $2\frac{1}{2}$ miles per hour.

4.45 p.m.—Boat stops and trawls are hauled.

Second haul, 5 p.m.—Trawls shot with full steam ahead.

5 to 11 p.m.—Fishing at $2\frac{1}{2}$ miles per hour.

11.30 p.m.—Trawls hauled.

Third haul, 11.45 p.m.—Trawls shot.

11.45 p.m. to 7.30 a.m.—Fishing.

It will be clear from this time-table that the only possible time for kite-flying is during the fishing for the first haul; or in the early part of the evening when the nets have been shot for the second time.

FIG. 1.—Mission Trawler, *Queen Alexandra*.

The meal times of the crew had also to be considered, as I needed the help of members of the crew. I found that, all things considered, the afternoon between 2 and 4.30 p.m. was the only time really suitable for

the kite work. This time is only short; and it has a further disadvantage in being the regular time of the skipper's watch below.

We will now consider the kite work itself. The first thing which had to be considered was the most suitable position for the kite winding-gear. There is very little spare room on the deck of a trawler, and the position of the masts, funnels, and sails made it difficult to choose the best position for the winch. It was decided that the raised deck right at the bow of the boat was the most suitable position; but it had many disadvantages.

In the first place a course had to be steered relative to the wind, which would keep the kite well to the side of the boat in order to prevent the kite wire becoming fouled in the rigging. Also when the kite was once up the boat could not be brought round; this was a great difficulty, for it prevented ascents being made on one or two suitable days on which fishing was proceeding over a small area of sea. It also necessitated a course being steered independently of the rest of the fleet, and this was not always possible.

With the kite engine so far forward the steam had to be conveyed a long way through a copper steam pipe. In this pipe great condensation took place, the condensed water causing much trouble when working the engine.

Another difficulty connected with the position of the winding-gear was that water broke over the bows of the vessel and made it impossible to work the gear even if the sea was only slightly rough. On account of the rigging and the smallness of the boat, and the fact that the course and speed could not be altered, it was found impracticable to use more than one kite at a time.

The great advantage claimed for kite-flying from boats is, that with little wind the lifting power of a kite can be greatly increased by steaming against the wind, while the strength of a strong wind can be virtually reduced by running before the wind. It is obvious that neither of these advantages can be obtained from a trawler which must steam constantly at the slow velocity of $2\frac{1}{2}$ miles per hour. In fact in no single particular has kite-flying from a trawler any advantage over kite-flying from land (that is considering the operation of kite-flying and not the meteorological results), but it has a great many disadvantages. Beyond the actual difficulties mentioned above there is the danger in getting away and bringing back a kite when there is so little working-room at one's disposal, and so much rigging, etc., on which the kite can break itself; then there is the motion of the vessel, which, while not affecting the kite, yet is a considerable inconvenience to those working it; there is also the danger of a kite falling in the water and being entirely lost on account of the inability to stop the boat; and added to all these there is a still greater dependency on the weather than there would be on land, reducing considerably the number of days available for kite-flying.

These are the considerations which have led to the conclusion stated above that kite-flying from a trawler although quite possible is not really practicable.

The season at which these experiments were made was the end of July and the first part of August 1905.

I left London on Friday morning, July 21, for Gorleston near Yarmouth, where the Mission Boat was being fitted out. My apparatus was got on

board, and steam and other connections made. We sailed from Gorleston on the Wednesday morning and arrived at the fleet in lat. 56° N., long. 6° E. on Friday afternoon. The first kite ascent was made on the following day.

I remained with the fleet until Thursday morning, August 17, when I left with the fish carrier for Billingsgate Market, where we arrived during the afternoon of the following day. Thus I was three weeks and two days at sea; but as only the time between the arrival of the Mission Boat at the fleet and the time of my leaving that boat could be used for kite work, I had (not counting Sundays) 17 days for kite-flying. During this time eight ascents were made, six of them giving good meteorological records.

In spite of the difficulties of the work, we were fortunate enough not to lose a single kite or instrument; in fact the only breakage we had was in landing the kite after the second ascent, when the kite struck the rigging and broke one stick.

I would like here to express to the Kite Committee how deeply indebted I feel to the Royal Mission to Deep-Sea Fishermen and to their servants for the great help they gave me to successfully carry through this work. I did not expect so much interest, nor could I have desired more ready help than was given both when fitting up the apparatus at Gorleston and when using it at sea. In particular I am indebted to Skipper Farman and to Mr. Hann, the chief engineer, who did all in their power to help me, often at considerable inconvenience to themselves. If kite-flying from a trawler was found not to be practicable it was through no want of willingness on the part of the officers and crew of the *Queen Alexandra*.

I will now give the meteorological results of the ascents made.

Ascent 1.—*Friday, July* 28.

(Lat. 56° N., long. 6° E.)

This being the first ascent, it was deemed advisable to use a small kite. The wind was not strong, so only a small altitude was reached. In order to obtain the maximum height possible under the circumstances, the kite was allowed to go out until the wire in the sag touched the sea, then it was hauled in at full speed, which caused the kite to mount. When a fairly good angle was attained the wire was let out again until it touched the sea once more. This process was repeated three times, when 3540 ft. of wire were out and touching the sea. The kite was then rapidly hauled in, an angle of 55° being attained.

The day was clear and bright, there being cumulus clouds all round the horizon but none overhead. To the south-south-west were a few feathery Ci. clouds. On plotting the numbers it is found that the curve connecting temperature with height is not straight, but is slightly convex to the abscissa. This point will be referred to later when discussing all the results together; it is enough to state here that this means that the temperature gradient decreases with height up to the height reached by the kite (about 2000 ft.). The mean gradient being $5\frac{1}{2}°$ per 1000 ft. The relative humidity curve simply shows an increase of humidity with height.

Results.

At start.—Sea 1-2 showing a little white. Wind steady from N.N.W. (3). Dry-Bulb 60°. Wet-Bulb 55°·5. Clouds Cu. 1, Ci. 2.

Time.	Height.	Temperature.	Humidity.
p.m.	Ft.	°	Scale Division.
2·0	0	60	8
2·35	740	55	6·2
2·40	840	55	6·8
2·42	970	53	6·5
2·45	650	56	6·8
2·49	1220	53	5·8
2·56	990	55	6·1
3·0	1230	54	6·0
3·3	1360	52	5·8
3·6	1800	51	8·5 (?)
3·16	990	55	6·0
3·30	0	62	7·0

At end.—Dry-Bulb 60°·2. Wet-Bulb 54°·2. Clouds Cu. 1, Ci. 2.

ASCENT 2.—*Monday, July* 31.

Owing to the course steered it was not possible to raise a kite in the afternoon; but an attempt was made in the evening. A good breeze was blowing and all went well at first, but soon we had trouble with the engine. Condensed water got into the cylinders, causing the pistons to hammer. The jar broke several cogs on the gear wheels. On putting on new cogs the same trouble occurred again, and it was decided to haul the kite in, the engine running fairly well when hauling. When 1000 ft. of wire still remained to be taken in, a set screw of the engine became loose, and it was necessary to haul in the rest of the wire by hand. This was a big job as the kite pulled hard in the breeze; but, thanks to the willing help of the crew, the kite was hauled in at last. On landing the kite dashed itself against the rigging and broke a stick, but the meteorograph landed unhurt. Owing to the trouble with the engine only a few observations could be taken and the height reached was not great (1260 ft.).

Results.

Temperature at start = 60°
„ „ 1260 ft. = 51° } Temperature gradient, 4°·7.

Hygrometer at start . 8
„ „ highest point 7 } Humidity increases with height.

At end.—Dry-bulb 59°. Wet-bulb 54°. Clouds, Cu. 3. Wind, 5 W.N.W. Sea 3.

ASCENT 3.—*Thursday, August* 3.

(Lat. 56°, Long. 5° 10′ E.)

In the afternoon, as there was a nice breeze and the ship was fairly steady, a large kite was sent up. The kite rose quickly and steadily

but did not experience an increase in wind strength. The sky was overcast with Alto-Stratus clouds, there being no Cumulus visible. When the kite had been up some time the Alto-Stratus clouds became of a very dark blue colour in the West-south-west and a squall of rain came along. The rain fell fairly heavily for some minutes but was not accompanied by much wind. Just as the rain came it was necessary to bring down the kite as it was near the time to haul the trawl.[1] This was unfortunate, as it would have been interesting to see if the rain produced any change in the upper atmosphere. After the rain there was a very good example of the wavy Stratus clouds which usually follow a thunderstorm, the appearance being that of soft waves of cloud spread over the sky.

Results.

At start.—Dry-bulb, 63°. Wet-bulb, 61°. Overcast with Alto-Stratus. Wind, 3 S.E. Sea 2, no white. Sea temperature, 60°·2.

Time.	Height.	Temperature.	Humidity.	Remarks.
	Ft.	°	Scale Division	
Begin	0	62	5·0	
1·57 p.m.	1430	55	8·0	
2·6 ,,	1580	55	8·5	
2·22 ,,	2400	52	8·5	
2·30 ,,	2400	52	8·8	
2·38 ,,	2790	51	8·8	
2·47 ,,	2940	51	8·5	
2·50 to 2·58 p.m.	...	...	...	Heavy rain squall.
2·59 ,,	3760	48	6·2	
3·3 ,,	4040	46	6·1	
3·7 ,,	3260	48	7·8	
3·12 ,,	2980	50	8·1	
3·17 ,,	1860	53	8·7	
End	0	62	4·5	

At end.—Dry-bulb, 62°. Wet-bulb, 60°. Sea temperature, 60°·2. Clouds overcast with fine thunder Stratus.

From the curve connecting temperature and height it would appear that the temperature gradient was constant above 1000 ft., and equal to 3°·5 per 1000 ft. Below 1000 ft. the gradient appears a little larger, viz. 5° per 1000 ft.

The relative humidity curve (Fig. 2) is very interesting. Up to a height of 890 ft., when the temperature was 56°, the air was very humid —4·7 scale division. Between this and 1430 ft. the air became rapidly drier. From 1500 ft. to 3000 ft. the air was exceptionally dry. Just as the kite had reached this height a rain squall passed over and it became necessary to haul in the kite; this process caused the kite to mount. The hygrograph now shows more humid air, and it is doubtful whether the humidity found above 3000 ft. is due to the shower or whether there was a layer of damper air there. As the kite descended it again registered great dryness down to 1760 ft. after which the air was more humid. At

[1] The time used in this work is Greenwich. A time nearer local time, but not at all accurate, was used for working the boat.

the same height as before (890 ft. with 56° temperature) nearly saturated air was met with and found to extend down to the surface.

The presence of the layer of very dry air through which the heavy rain fell is very interesting, and no doubt accounts for the total absence of Cu. clouds.

ASCENT 4.—*Saturday, August* 5.

(Lat. 56° N., Long. 5° E.)

A good breeze was blowing from the South-south-west and the sea was running fairly high so a small kite was sent up.

The day was fine and bright at first but just before the ascent the sky became overcast with Ci. and Alto-Stratus. Then a rain squall came from the South-south-west, but only the fringe of it touched us, so that it only rained for a few minutes. After this detached clouds were driven across the sky; it looked as though the kite were in the cloud layer, but the trace shows that the kite was well above the clouds in a very dry layer of air.

Results.

At start.—Dry-bulb, 63°. Wet-bulb, 61°. Wind 5-6 SSW. Overcast with Ci. and S. Heavy squall in SSW. Sea, 3-4. Sea temperature, 60°.

Time.	Height.	Temperature.	Humidity.	Remarks.
	Ft.	°	Scale Division	
1·31 p.m.	0	62	5·0	
1·34 ,,	1160	58	4·0	
1·39 ,,	2210	53	3·7	Highest humidity (clouds).
1·42 ,,	2500	52	3·9	
1·58 ,,	3050	52	4·1	
2·3 ,,	3190	51	6·5	Dry layer reached.
2·9 ,,	3090	51	6·8	
2·27 ,,	3480	50	6·5	
3·8 ,,	3870	49	7·2	
3·30 ,,	4680	45	6·5	
3·47 ,,	5130	45	7·5	
4·12 ,,	4350	47	7·5	
4·16 ,,	4250	47	5·2	Leaves dry layer.
4·17 ,,	4060	48	5·2	
4·25 ,,	3620	49	5·5	
4·35 ,,	3030	50	5·0	
4·50 ,,	1970	54	5·0	
4·58 ,,	1050	57	4·0	In clouds.
5·8 ,,	0	62	5·5	

At end.—Dry-bulb, 63°. Wet-bulb, 61°·2. Sea, 3-4. Clouds, Ci., S. and Scud.

Temperature gradient above 2000 ft. is 3°·0 per 1000 ft.
,, ,, from 1000 to 2000 ft. is 3°·5 per 1000 ft.
,, ,, from 0 to 1000 ft. is 4°·8 per 1000 ft.

Humidity.—The relative humidity curve is again very interesting (Fig. 3). As the kite rose the air became more humid, being practically saturated between 1000 and 3000 ft. Just above 3000 ft. a layer of

dry air was suddenly reached. The air remained dry as high as the kite rose. When the kite descended it left the very dry air higher than it had met it (4250 ft.), but did not meet saturated air until it had fallen to between 1500 and 1000 ft. At 1000 ft. the kite was in the cloud layer. From this it would appear as if the saturated air encountered during the ascent were gradually mixing with the dry air above. It is exceedingly interesting to notice that the dry layer found on the previous Thursday still remained, although a layer of more humid air carrying scud had found its way in below.

ASCENT 5.—*Tuesday, August* 8.

(Same lat. and long.)

This ascent proved unsatisfactory in that soon after starting the clock of the meteorograph stopped, so that only the temperature of the highest point could be read from the meteorograph trace. But it was a

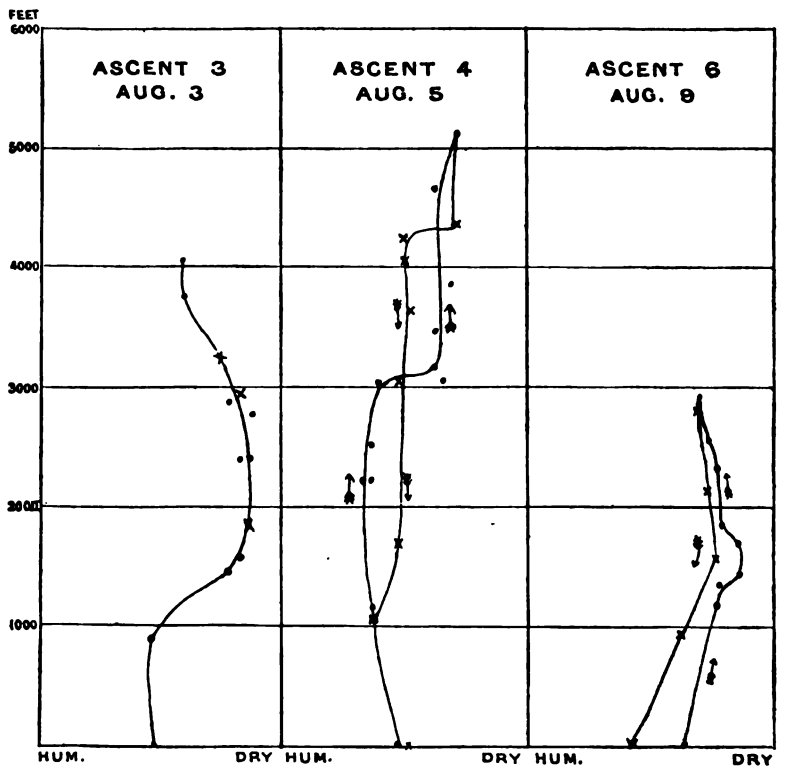

FIG. 2. FIG. 3. FIG. 4.

Relative Humidity Curves.

somewhat interesting ascent from the fact that it showed how in this case the wind fell off in strength in the upper atmosphere before at the surface.

At the start a fairly strong breeze was blowing from the South, so

that it was questionable if a large or a small kite should be used. We decided on a large one, and sent it up at 1.44 p.m. In order to get a convenient wind we had to leave the fleet. As we did not wish to get too far away from the proper fishing ground, we decided to get a rapid ascent and descent. The idea was to run out about a mile of wire as quickly as possible and then rapidly haul in; it was expected that with the large kite and stiff breeze we should by this method get a good angle and a good altitude in a short time. On letting the kite rise it was at once seen that the pull became less and the wind came more from the Westward. When about 4800 ft. of wire were out the pull was so small that the wire did not clear the water, and it was seen that the kite was falling rapidly. The only thing to be done was to haul in as quickly as possible. As the kite got lower it again experienced a stronger wind, and a good angle was obtained.

From this we see that the wind was only a surface wind, and did not extend much above 2000 ft. The upper wind was from the South-south-west, that below being from the South.

The surface wind did not last long, but the upper calm extended downwards; at 6 p.m. there was very little wind at the surface.

From the trace it appears that the temperature gradient up to 2000 ft. was between 3°·5 and 4°·0 per 1000 ft.

Ascent 6.—*Wednesday, August* 9.

(Lat. 56° N., Long. 4° 40′ E.)

In the afternoon a kite was sent up. There was only a little wind, and only a moderate height could be attained.

The sky was overcast with Alt.-Cu. which were low and dark. Under these, but very high, was a little scud. The wind was from the South-south-west and did not change higher up. The clouds became heavier, and as we finished a few drops of rain were falling. An hour and half afterwards heavy rain was falling; and later in the evening a very heavy thunderstorm broke out.

Results.

At start.—Dry-bulb, 64°. Wet-bulb, 60°. Wind, 3 SSW. Sea, 1. Overcast with thick Alt.-Cu. Sea temperature, 60°·7.

Time.	Height.	Temperature.	Humidity.	Remarks.
	Ft.	°	Scale Division	
Start.	0	64	6·6	
2·26 p.m.	1170	57	7·9	Reached dry level.
2·27 ,,	1350	56	8·0	
2·32 ,,	1430	57	8·9	Greatest dryness.
2·36 ,,	1700	55·5	8·8	
2·43 ,,	1840	55·5	8·0	
2·53 ,,	2320	54	8·0	
3·1 ,,	2570	53	7·5	
3·9 ,,	2950	52	7·1	Highest point.
3·15 ,,	2820	52	7·1	
3·19 ,,	2150	54	7·5	
3·25 ,,	1550	56	7·9	Greatest dryness.
3·29 ,,	920	58	6·5	Left dry layer.
End.	0	61	4·4	

At end.—Dry-bulb, 62°·8. Wet-bulb, 60°·2. Wind, 3-4 SSW. Sea, 1. Overcast, high Str. Little rain falling.

Temperature Gradient.—Over 1000 ft., 3° per 1000 ft.
Under „ 5¼° „

Relative Humidity.—This ascent again revealed great dryness in the upper air; but for the first time we have the air becoming drier directly from the surface without first becoming more humid (Fig. 4). The humidity rapidly decreased until the dry layer was reached at about 1000 ft. Afterwards there was little change except that at 1600 ft. there appears to have been an exceptionally dry layer; at greater heights than this latter the air became more humid again.

This great dryness is of considerable interest considering that rain was falling through it, and that later in the evening a very severe thunderstorm developed.

Ascent 7.—*Saturday, August* 12.
(Lat. 55°, Long. 4° 30′ E.)

Results.

At start.—Dry-bulb, 60°. Wet-bulb, 57°. Heavy Cu. and Ni. 9. Wind, 4-5 WNW. Sea, 2-3.

Time.	Height.	Temperature.	Humidity.
	Ft.	°	Scale Division.
Start.	0	58	6·5
1·50 p.m.	850	53	4·2
1·57 „	1430	52	4·0
2·4 „	1870	50	4·0
2·10 „	2300	48	4·4
2·33 „	4470	42	4·0
2·46 „	5100	40	4·0
3·00 „	5800	38	3·8
3·4 „	5430	37½	3·5
3·12 „	4820	39	3·9
3·17 „	3730	42	4·0
3·27 „	1470	50	4·3
End.	0	58	6·2

At end.—Dry-bulb, 60°. Wet-bulb, 57°·5. Wind, 4-5. Sea, 2-3. Clouds, Ni. and Cu. 9.

This was one of the most successful ascents. The previous day had been rough and squally; but during the Saturday morning the sea had moderated and wind had become less squally. Heavy Cu. and Ni. clouds nearly covered the sky. The highest point reached was attained during this ascent, the kite rising 5800 ft.

Temperature Gradient.—Above 2000 ft., 3°·0 per 1000 ft.
Below 2000 ft. and above 1000 ft. } 3°·8 „
Below 1000 ft., 5°·5 „

Humidity.—The kite soon reached the cloud level and did not pierce it. Here at last we see no trace of the dry layer which had been so prominent in the previous ascents.

ASCENT 8.—*Wednesday, August* 16.

(Lat. 55° 15′ N., long. 4° 45′ E.)

There was very little wind, but as this was the last opportunity of getting a kite up, an attempt was made. With difficulty 3000 ft. of wire were got out, but the kite was very unsteady, rising and falling with changes in the wind.

Results.

At start.—Dry-bulb, 62°·5. Wet-bulb, 57°. Wind, 2 NNE. Clouds, 4 Cu. Sea, 1-2. Sea temperature, 61°·2.

Time.	Height.	Temperature.	Humidity.
	Ft.	°	Scale Division.
Start.	0	59	6·8
2·49 p.m.	1430	55	6·0
2·56 ,,	1230	55	6·2
3·3 ,,	2000	53	5·2
3·7 ,,	2050	52	5·0
3·13 ,,	1170	55	6·0
End.	0	62	6·5

At end.—Dry-bulb, 60°. Wet-bulb, 56°·5. Clouds, 2 Cu. Wind, 1-2 N. Sea, 1.

Temperature Gradient.—From these few results the temperature gradient appears to be 4°·2 per 1000 ft.

Humidity.—The humidity increases with the height up to 2000 ft.

GENERAL REMARKS.

Two points are of interest in reviewing these results. The first is the layer of dry air met with on the 3rd, 4th, and 6th ascents. The first and last of these three show indications of more humid air above the layer of very dry air; but although the kite rose over 5000 ft. on the fourth ascent, it did not pierce the dry layer on that occasion. It would be interesting to know if the same dry layer had existed from August 3 to 9; or if it were only chance that a dry layer was met on these three consecutive ascents. I am inclined to believe that the former was the case, for the wind remained Southerly all the time, varying between South-south-west and South-south-east, although the Daily Weather Maps do not show any persistent Southerly current. The wind changed on August 10 to North-west, and subsequent ascents showed no trace of dry air.

The pressure systems on the three days of these ascents were of quite different types: ascent 3 was made in the "saddle" between two "lows," ascent 4 was made on the outskirts of a low in the North-west, and at the time of ascent 6 there was a very even distribution of pressure. It will be interesting to find from the results of the International ascents made on August 3 if this dry layer were of any considerable extent.

The second point of interest is the apparent high temperature gradient in the first thousand feet of ascent. I say "apparent" because Mr. Dines thinks it is due to the meteorograph not being at the air temperature

before the ascent, but at a higher temperature due to the heating effect of the ship itself. I mention this as a point which might be more fully inquired into. The following table shows that in these ascents the effect was very persistent.

TEMPERATURE GRADIENT.

	0 to 1000 feet.	1000 to 2000 feet.	Above 2000 feet.
	°	°	°
Ascent 3	5·0	3·7	3·5
Ascent 4	4·8	3·5	3·0
Ascent 6	5·3	3·0	3·0
Ascent 7	5·5	3·8	3·0
Mean	5·1	3·6	3·1

DISCUSSION

The PRESIDENT (Mr. RICHARD BENTLEY) remarked that modern Meteorology was entering upon a new and most important phase. Earlier Meteorology had dealt very fully with observations on, or very near, the earth's surface, but we were now embarking upon a systematic and international investigation of the upper air. Our nautical colleagues had started so much earlier that they had already achieved great part of their task. The bed of the ocean was fairly well explored, either in course of ordinary charting or by means of scientific expeditions or by the aid of cable-ships, and the permanent surface currents had been examined and most of them recorded. The purely marine work was the easier of the two, having defined limits, *i.e.* both the upper and under surfaces were ascertained.

With the exploration of the atmosphere we had only *one* known surface. We knew something of the conditions where the earth's surface was in contact with the atmosphere,—the deflections of winds by hills and mountains, the warm-air areas, the influences of ascending vapours, etc.,—but the time had now arrived when it was necessary to enlarge the scope of our researches and to make an organised effort to investigate the movements and conditions of the upper air so gallantly attempted, years ago, by one of our past Presidents, Mr. Glaisher, and by others. To-day we had abroad the assistance of M. Hergesell, of M. Teisserenc de Bort, etc. A great aeronautical exhibition was on the point of being held at Milan. Air-ships and navigable balloons were being experimented with, and ascents made by military balloons yielded also much valuable information. Much was to be hoped for from the concerted and combined efforts of investigators both at home and abroad, and especially so when these were synchronous.

The Society is especially grateful, therefore, to-night to Mr. Simpson, Mr. Cave, and Mr. Dines for having given to us simultaneously and in so interesting a manner accounts of their recent work in such wide apart regions as the North Sea, the West Indies, and Surrey respectively—work achieved in each case under circumstances of great difficulty.

Dr. W. N. SHAW thought that the Royal Meteorological Society had seldom had a more conspicuous example of the wide reach of meteorological work than was before them that evening. Observations of the temperature and humidity of the upper atmosphere had been carried out, on the one hand, on a fishing-boat on the North Sea, and, on the other hand, with the assistance of negroes

in Barbados. And when to these were added observations during the recent solar eclipse, the combination could well be regarded as a red-letter event in the annals of the Society. He thought it unfortunate that Mr. Dines had been unable to get a kite up till the maximum phase of the eclipse had passed, as it would have been interesting to see if there had been any decrease of temperature when the shadow of the moon came on. Speaking from recollection, he had been informed that a variation of 3° in the temperature had been observed, and he would like to know if any such difference took place in the upper air. Mr. Cave's observations were exceedingly interesting. In one ascent he recorded a high humidity at one level with the ascending kite and a low humidity at the same level with the descending kite. It was remarkable that the moist layer of air through which the kite had passed on the ascent should not be met with on its way down. This was in contrast with the dry layer of air that Mr. Simpson had observed over the North Sea. Whereas Mr. Simpson had found similar conditions remaining almost constant for a week, Mr. Cave had recorded contrary results within the interval of a short ascent. Mr. Simpson's story of his difficulties and experiences in the North Sea was quite thrilling, and the results were both interesting and valuable. He (Dr. Shaw) hoped they would prove to be the beginning of organised kite investigations over the sea in British ships. He was not depressed by Mr. Simpson's statement of the impracticability of the work on a trawler. He had used the same word himself of observations on land in this country, but Mr. Dines had proved the contrary. Mr. Simpson pronounced kite work on a trawler to be impracticable, and then demonstrated the contrary by his paper. A year ago such work would have been called impossible. He fully endorsed the cordial vote of thanks to the several authors of the papers for the work that they had accomplished.

Mr. E. S. Bruce said he could fully endorse the remarks of the previous speakers as to the extreme value of the kite observations. He thought such investigations would form the true Meteorology of the future, though of course the study of the surface conditions of the atmosphere must still be continued which, under the name of Climatology, had proved such a great benefit to mankind. He thought the pioneers of these difficult investigations could not be congratulated too warmly, and he hoped other observers would be led to take up the work. Such observations were of immense value to aeronauts, and on behalf of the Aeronautical Society of Great Britain, whose honorary secretary he was, he again congratulated the Society on the valuable work they were doing in providing for these investigations. He hoped that the use of "Ballons Sondes" would prove of value in future observations. One such Ballon Sonde had made an ascent of 14 miles (a height very difficult for kites to attain) and had brought down a record of temperature. This record, he admitted, was open to considerable doubt, but it was an instance of the remarkable height reached by these small balloons. Mr. P. Y. Alexander had made frequent use of them in this country, and he hoped they might prove of value in future investigations.

Mr. G. C. Simpson, in reply, said that kite-flying from a trawler is quite practicable if one is prepared to spend three weeks on a trawler and to get only eight ascents, to say nothing about the feeling of being a nuisance to those in charge of the boat. He thought a trawler was the worst boat possible for rolling. He also wished to thank Mr. Dines for his valuable help and suggestions before he undertook the investigations. Day after day Mr. Dines had instructed him at Oxshott, and he felt bound to admit that it was only by such assistance that the carrying out of the work was made possible.

Mr. W. H. Dines, replying to Dr. Shaw, said that he did not think it likely that the change of temperature produced by the shadow could extend to any great height, for it was known that the daily temperature variation was very small, even if it existed at all, save in the lower strata. In this case, however, the

doubtful point was whether the kite was above or below the upper surface of the clouds.

He (Mr. W. H. Dines) congratulated Mr. Simpson on the results he had obtained, and more particularly on his having carried out the work without any loss of apparatus. Having flown kites himself from the deck of a small screw tug in bad weather, he could fully appreciate the difficulties that Mr. Simpson had touched upon. He considered that a low humidity was an unfailing index of a descending current, and the question of the extent and duration of these layers of dry air was of great interest. He had that morning found a humidity of about 15 per cent at 7000 ft. lying above a sheet of clouds at 5000 ft.

Rainfall of China and Korea.

Mr. T. Okado contributes a paper on the Rainfall tables for China and Korea, in the September number of the *Journal of the Meteorological Society of Japan*.

The following table gives the Mean Annual Rainfall at 37 stations in China and Korea, for the years 1892-1901 :—

Station.	Latitude.	Longitude.	Rainfall.	Days of Rain.
			ins.	
Peking	39° 57′ N.	116° 28′ E.	26·61	71
Wonsan	39 9	127 33	44·80	64
Hauki	38 4	120 39	16·66	40
Chefoo	37 34	121 32	22·94	57
Chemulpo	37 29	126 37	35·64	84
Shangtung Cape, N.E.	37 24	122 42	21·11	43
Shangtung Cape, S.E.	37 24	122 42	26·45	52
Wei-Hai-Wei	37 10	122 10	21·08	71
Tintau	36 4	120 18	26·87	79
Fusan	35 5	129 6	44·74	76
Chinkiang	32 12	119 30	41·02	93
Shaweishan	31 25	122 15	36·79	74
Wuhu	31 22	118 22	40·07	90
Zikawei	31 12	121 21	39·75	131
North Saddle	30 52	122 40	29·40	75
Gutzluff	30 50	122 10	32·43	67
Hankow	30 33	114 20	50·24	92
Ichang	30 12	111 19	41·70	98
Steep Island	30 12	122 36	33·41	79
Ningpo	29 58	121 44	54·14	124
Kiukiang	29 44	113 48	52·22	106
Chunking	29 31	104 11	38·56	134
Wenchow	28 0	120 35	59·10	145
Pagoda	26 8	119 38	47·58	106
Middledog	25 58	120 2	43·90	110
Tournabout	25 26	119 56	39·43	84
Ockseu	24 59	119 28	34·92	70
Amoy	24 27	118 4	42·24	97
Chapel Island	24 10	118 13	32·01	65
Wuchow	23 29	111 20	43·76	102
Swatow	23 20	116 43	57·50	111
Lamocks	23 15	117 18	39·40	68
Canton	23 7	113 17	50·88	...
Breakerpoint	22 56	116 28	61·01	87
Longchow	22 22	106 45	39·77	107
Hongkong	22 18	114 10	78·94	149
Macao	22 11	113 33	63·60	110
Waglan	22 10	113 30	47·63	83
Pakhoi	21 29	109 6	77·95	123
Kiungchow	20 3	110 20	50·71	...

INVESTIGATION OF THE UPPER AIR AT BARBADOS BY MEANS OF KITES.

By C. J. P. CAVE, F.R.Met.Soc., and W. H. DINES, F.R.S.

[Read December 20, 1905.]

The observations dealt with in the following paper were taken by Mr. Cave in the island of Barbados, lat. 13° 15′ N., long. 59° 35′ W., at the end of April and the beginning of May 1904. The station from which the kite ascents were made is situated in the north end of the island, on the St. Nicholas estate, 660 ft. above the sea. The kites, made by the Cambridge Scientific Instrument Co. from a pattern supplied by Mr. Dines, were let out from a winch which was worked by hand; no great speed in winding in was therefore possible, or greater heights might have been obtained; on an average the rate of winding in was rather under a mile and a half an hour. The instruments used were of the type made by MM. Richard Frères; they were tied in an open basket which was attached to the wire at some distance below the kite. They were kept in a room in which all the windows were open, and through which the wind was blowing till all was ready for the ascent; but as they had to be taken out some hundred yards, and as some delay frequently occurred before they could be sent up, the traces all show a rise of temperature just before the commencement of the ascent, and for the same reason they show an undue rise at the end of each ascent.

The Trade Wind blows with great regularity in the island of Barbados during the winter months, its direction being usually East-north-east. Now and then, however, the wind becomes light, and is from a more Southerly point, and rain often falls. These conditions become more common as the season advances, and unfortunately when these observations were begun the Trade wind was slackening, and on several days kite ascents were consequently not possible. On some of the other days, though it was possible to get a kite up, it was found that it would not attain any great height, showing that the wind slackened considerably at a slight altitude. This was also shown by the clouds on these days. Cumulus clouds of apparently small dimensions were noticed having their tops inclined against the direction of the wind, showing that they had reached a level where the wind had slackened; on other days when the Trade was blowing from the normal direction, clouds, apparently much higher, had no trace of inclination in the direction contrary to that of the wind.

On several days halos were observed, and when this was the case filmy Cirrus clouds were generally seen coming from the west. On one day, April 25, there was some distant thunder, which is a most unusual thing in Barbados so early in the year.

The following results were obtained (the heights are measured from the surface):—

April 25.

Ascent commenced at 2.30 p.m. and ended at 5.30 p.m.
Maximum height 1960 ft.
Temperature decrease 5°.
Humidity 70 to 80 per cent throughout.

April 28.

8.42 a.m to 10.28 a.m.

Maximum height 2050 ft.
Temperature decrease 9°.
Humidity 60 per cent at the surface, increasing to 90 and then decreasing to 60.

April 28.

11.29 a.m. to 2.6 p.m.

Maximum height 2100 ft.
Temperature decrease 9°.
Humidity 60 to 75, then decreasing to 60 per cent.

April 29.

8.45 a.m. to 1.16 p.m.

Maximum height 3400 ft.
Temperature decrease 16°.
Humidity 60 at surface, 95 at 1600 ft. on ascent, 70 at the top to 30 per cent at 2300 ft. on descent.

April 30.

8.53 a.m. to 2 p.m.

Maximum height 4800 ft.
Temperature decrease 8° to 1660 ft., 14° to 3330 ft., 18° to 4800 ft.
Humidity 60 to 80 per cent at 2500 ft. to 55 at 3300 ft., then increasing.
Trace partially defective. The height may have exceeded 4800 ft.

May 2.

10.22 a.m. to 12.52 p.m.

Maximum height 2750 ft.
Temperature decrease 13°.
Humidity from 50 to 80 per cent at 2750 ft.

May 3.

2.17 p.m. to 5.26 p.m.

Maximum height 3700 ft.
Temperature decrease 9° to 1660 ft., 15° to 3900 ft.
Humidity increasing, then decreasing, with an average of 50 per cent for the ascent, but reaching 95 per cent at 2600 ft. on the descent.

May 4.

8.20 a.m. to 11.40 a.m.

Maximum height 3400 ft.
Temperature decrease 16°.
Humidity 50 to 80 per cent at 2000 ft. to 40 per cent at 3400 ft.

May 6.

Time ?

Maximum height 2700 ft.
Temperature decrease 7° to 1660 ft., 9° to 2700 ft.
Humidity 60 to 90 per cent at 1200 ft. to 50 at 2700 ft.

The surface temperature was in every case close to 80°. The average gradient per 1000 ft. for the first 1660 ft. (500 metres) is 5°·1, and for the second step of 1660 ft. 4°·0. It is noteworthy that the traces

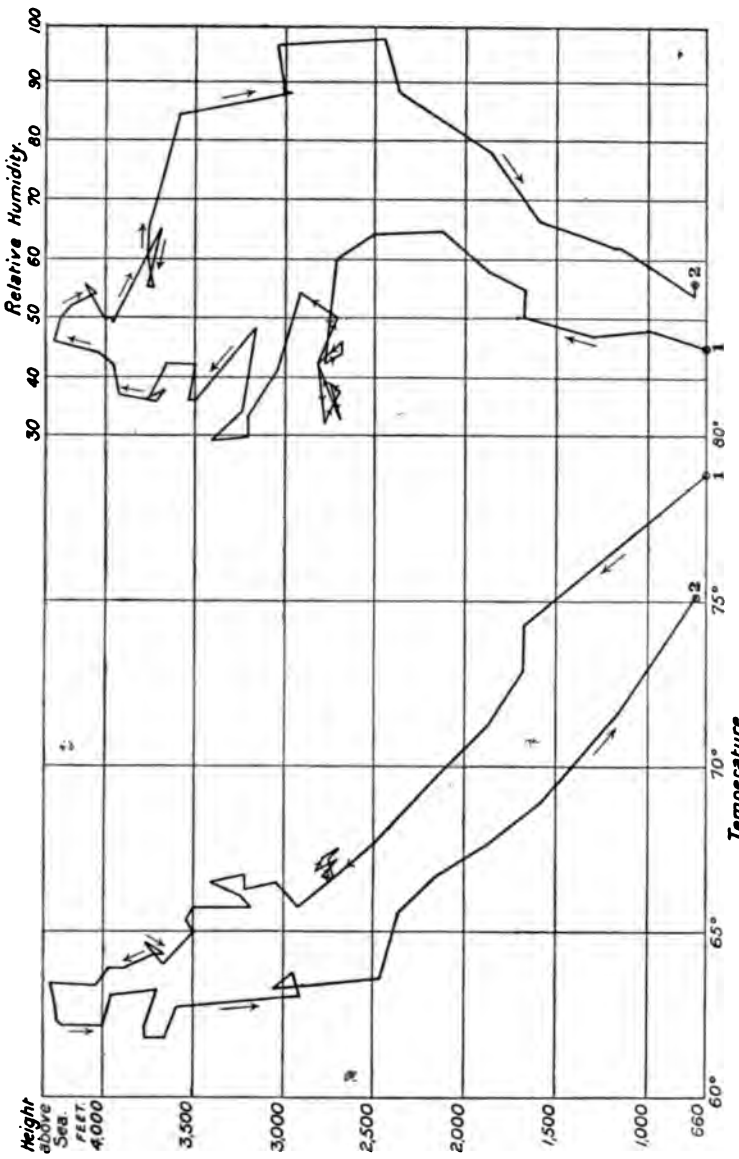

FIG. 1.—Temperature and Relative Humidity, May 3, 1904.

generally show a higher temperature during the ascent than during the descent, a result perhaps due to the lag of the thermograph; the gradients have been deduced from the mean of the two values.

The humidity traces show generally a value of about 60 per cent at the surface, rising to 80 to 90 per cent at heights of from 1000 to

2000 ft., and then falling off again in some cases to 50 per cent or less as the height increases.

The values are lower than one might have expected over a tropical ocean. The increase is of the ordinary kind, but the maximum value occurs at a far lower elevation than is the case in Europe. It is probable that the relative humidity forms an extremely accurate index to the vertical circulation, a low humidity indicating a descending current of air; and so we may infer that there is some settling down of the atmosphere over the region of the smaller West Indian Islands in April and May.

The most typical Trade Wind days during the period of the observations were April 29 and 30 and May 3. On April 30 the greatest height was reached, namely 5460 ft. above the sea, and perhaps more, for the barometer trace is defective. On this day, owing to a defective fastening, the second kite slid along the wire till it reached the instrument basket, which it seems to have turned over, detaching the thermometer pen; the height-temperature curve can therefore only be given for the ascent. While the kite was slipping there was a considerable fall, but as soon as the second kite was stopped by the fastening of the meteorograph basket there was a sudden rise, which appears on the trace to have been 2520 ft. in four minutes; the second kite finally broke loose and fell into the sea; this was the only accident either to kites or instruments during the course of the observations.

On two days there was a great difference in the humidity of the air during the ascent and descent; on April 29 the hygrometer showed saturation at a height of about 2300 feet above sea level at 10 a.m.; at the greatest height reached on this day, namely about 3800 ft., the hygrometer showed readings of between 60 and 70 per cent. On the descent an extremely dry layer was met with at about 2700 ft., the hygrometer reading being only about 30 per cent; this was a few minutes before 1 p.m. On May 3 (Fig. 1) a dry layer was met with during the ascent at about 2600 ft. at about 3 p.m. The air remained extremely dry up to 4300 ft., the greatest height attained a few minutes after 4 p.m., though now and then the hygrometer readings rise temporarily owing probably to the extension of clouds into the dry layer, the kite every now and then being hidden by passing clouds. On the descent the humidity increased rapidly; at about 4300 ft. it was 45 per cent; at 3600 ft. at about 4.45 p.m. it had increased to 75 per cent; it increased to about saturation at 2600 ft. soon after 5 o'clock, and then decreased gradually to about 55 per cent, when the ground was reached at 5.26.

Our thanks are due to Sir Daniel Morris, Imperial Commissioner for the West Indies, for kindly supplying the barometer and thermometer readings taken at the Botanic Station from April 24 to May 7. The Botanic Station is 181 ft. above the sea, and is therefore about 480 ft. below St. Nicholas, from which it is distant about 18 miles.

TEMPERATURE CHANGES DURING THE PARTIAL SOLAR ECLIPSE OF AUGUST 30, 1905, ON THE SURFACE AND AT 3000 ft. AT OXSHOTT.

By W. H. DINES, B.A., F.R.S.

[Read December 20, 1905.]

ALTHOUGH the eclipse of August 30, 1905, was only a partial one in England, near London rather more than three-quarters of the sun's face was covered, and in consequence more than three-quarters of the heat-supply was cut off. It is well known that a fall of temperature generally accompanies the passage of the shadow during a total solar eclipse and that this change of temperature suffices to produce a noticeable wind; but the height above the earth's surface to which the temperature change extends is unknown. It was intended therefore to utilise the opportunity and to obtain if possible thermograph traces from the surface, from a height of 1000 ft., of 3000 ft., and from the maximum height at which a kite could be maintained during the eclipse; but unfortunately only a part of the programme could be carried out.

At the surface the wind was very light from the North-west, registering hardly five miles per hour on the anemometer, but the cloud motion showed that there was a good wind above. After some unsuccessful attempts, at 1 p.m. a kite was got through the surface calm and reached a strong upper current, but the eclipse was then half over. It was fairly certain that no change of temperature would occur below the dense layer of clouds which covered the sky, so the kite was allowed to rise as rapidly as it would, and in twenty minutes it had disappeared behind the clouds. By 1.25 p.m. 4500 ft. of wire had been run out, and the kite and meteorograph, as it subsequently appeared, had reached a vertical height of 3100 ft. As soon as the wire had ceased to run out the kite rose rapidly through another 400 ft., and it remained until 2.35 p.m., when the ascent was continued, at a height that varied but little either way from 3500 ft. This fortunate result was due to the unusual steadiness of the wind, the day presenting conditions that were exceptionally favourable.

The results obtained are given in the following table.

P.M.	Height. ft.	Temperature. °	P.M.	Height. ft.	Temperature. °
1.0	0	51	3.0	4800	41
1.20	3100	42	3.10	3950	45
1.25	3550	41	3.20	4050	43
1.40	3600	41	3.37	5850	37
2.0	3350	42	4.0	7200	31
2.20	3500	42	4.18	4000	42
2.35	3500	42	4.28	3550	41
2.40	4200	41	4.40	in	53
2.48	4250	43			

It appears from this table that a trifling rise of temperature occurred as the shadow passed off, but the rise is so slight that it would be rash to assert that it was caused by the eclipse, especially as the same temperature was found at 3500 ft. elevation at 4·28 as at 1.25 p.m.

The under surface of the cloud layer, which in the neighbourhood of London completely obscured the sky, was 2000 ft. high. It seems probable that the kite was above the clouds and that the cloud layer was only a shallow one, for the occupants of a balloon which ascended from London at 12.30 p.m. had a clear view of the eclipse; and also when the kite was drawn in at 4.28 p.m., and had just passed through the same clouds, it was not at all wet, as it certainly would have been had the descent through the clouds occupied any appreciable time.

A meteorograph similar to that sent up in the kite was suspended in a tree from 11.40 a.m. to 4.40 p.m. It too showed a small increase of temperature from 1.30 to 2 p.m., the values being

Noon 51°	1 p.m. 51°	1.30 p.m. 52°	2 p.m. 53°
2.30 p.m. 52°	3 p.m. 53°	4 p.m. 53°.	

The extremes for the six hours in question did not show a difference of 3°.

It is unfortunate that the light wind of the morning prevented fuller observations being obtained. The upper wind was strong, the velocity shown by a balloon that travelled from London to Shoreham being about 35 miles per hour. The early morning was clear and the evening partially so, but during the eclipse the sky was covered save for a trifling break of a minute or two at 1.40 p.m.

Scotia Bay Meteorological Station.

The Argentine Government have decided to keep on this station for still another year, and have appointed Mr. Angus Rankin, late of the Ben Nevis Observatory, to take charge. Mr. Rankin left Edinburgh for the south on October 11, and was accompanied by two other former members of the Ben Nevis staff, Mr. R. H. MacDougall and Mr. William Bee.—*Scottish Geographical Magazine*, November 1905.

COMPARISON BETWEEN GLAISHER'S FACTORS AND FERREL'S PSYCHROMETRIC FORMULA.

By J. R. SUTTON, M.A., F.R.Met.Soc.

[Read December 20, 1905.]

It is a curious circumstance that Glaisher's *Hygrometrical Tables*[1] should differ so considerably from Tables computed by means of a so-called psychrometric formula, seeing that both are supposed to be derived from direct observation of the dew-point made at different altitudes and in different climates. Thus, to take an example, for an air temperature of 100°, at the sea-level, there is a difference of 4° in the alleged dew-points between Glaisher's and Marvin's Tables[2] for all wet-bulb temperatures lying between 81° and 88°; or, to express the same thing in another way, there is a difference of more than one-tenth of an inch in the alleged vapour-tensions.

It is true that Glaisher's Tables seem to imply mean conditions of ventilation, whereas Marvin expressly postulates the use of the whirled or aspirated psychrometer. The due allowance for this would give a somewhat higher value of the dew-point in a strong wind, and a lower value in a calm, than we find in Glaisher's Tables.

The most serious discrepancies between the same two authorities, however, occur when the wet-bulb is, relatively to the dry-bulb, very low. Thus for a temperature of 100° in the shade, and a wet-bulb reading 60°, the dew-point as computed by means of Glaisher's factors is 37°·2, and the relative humidity 12 per cent. According to Ferrel's psychrometric formula, the same elements are 12° and 4 per cent. Also for a temperature of 50° in the shade, and a wet-bulb reading 34°, Glaisher would give a dew-point of 17° and a relative humidity of 26 per cent, whereas Marvin would give − 13° and 5 per cent.

There is one fundamental difference between Glaisher's method and Marvin's, namely, that with the former there is not any implied lower limit to the reading of the wet-bulb: that is, the formula

$$t - t_0 = G\,(t - t_1)^{\,3} \quad \ldots\ldots \quad (1)$$

always gives a positive value to the vapour-tension in the free air whatever be the assigned wet-bulb reading, and therefore a zero humidity is never obtained. In fact, if for any given temperature of the dry-bulb we take the temperatures of evaporation as abscissæ and the corresponding relative humidities as ordinates, in plane co-ordinates the resulting curve is essentially asymptotic, and the axis of x meets it in two points at infinity. On the other hand, the relative humidities computed by means of Ferrel's formula run down very quickly to zero, as will be seen by the following Table.

[1] J. Glaisher, *Hygrometrical Tables*, Seventh Edition, 1885.

[2] C. F. Marvin, *Psychrometric Tables*, 1900. They are computed from Ferrel's formula

$$e = e' - 0{\cdot}000367\mathrm{P}(t - t')\left(1 + \frac{t' - 32}{1571}\right).$$

[3] Where t is the temperature of the dry-bulb, t_1 that of the wet-bulb, t_0 that of the dew-point, and G a constant for any assigned temperature.

Dry Bulb.	Wet Bulb.	Relative Humidity.	
		Marvin.	Glaisher.
°	°	%	%
0	−3	0	25
10	+5	0	7
20	13	0	5
30	20	0	15
40	27	0	28
50	33	0	24
60	39	0	22
70	44	0	18
80	49	0	15
90	53	0	12
100	57	0	10

Even if we allow that these readings of the wet-bulb are possibly too high for a zero humidity, yet it is not a likely supposition that in an absolutely dry air, however swift the current, the wet-bulb should fall to any excessively low temperature, to say nothing of falling to the absolute zero of temperature.[1] Apart from this, some of the main objections to Glaisher's Tables seem to depend largely on what is regarded as a lack of philosophical basis for his formula. It is a curious commentary on this, however, that for reasonable altitudes, and excluding exceedingly arid conditions, Marvin's numbers may be proved by trial to agree pretty closely with the formula

$$AB\,(t - t') = 100 - H \quad \ldots\ldots \quad (2)$$

where t is the temperature of the dry-bulb;
t' is the temperature of the wet-bulb;
H is the relative humidity;
A and B factors to be determined.

A may be taken as approximately equal to t'/t; and B is rather less than the quantity found by putting $t = 2\,t'$, $H = 0$, in the above formula. For altitudes up to 5000 feet this formula may be trusted to give the relative humidity within 5 per cent (and the vapour-tension within ·01 inch), and that degree of approximation may be useful to travellers who happen to be unprovided with Tables but can remember how the co-efficients are deduced.[2] For example, suppose a traveller unprovided with Tables to observe the dry-bulb 70° and the wet-bulb 50°, what is the relative humidity? First, to find B, we put

$$A = t'/t = 35/70 = 1/2$$
$$H = 0$$
$$\therefore (B/2)\,(70 - 35) = 100 - 0\ ^{3}$$
$$i.e.\ B = 5{\cdot}7 \text{ approximately.}$$

[1] According to Ferrel's formula the wet-bulb would fall to the absolute zero in empty space. For if $P = 0$, then $e = 0$ (since the vapour-tension is a part of the barometric pressure), and therefore $e' = 0$. It is worth notice, too, that if P be made very great e will become a minus quantity. A psychrometric formula, however, is not strictly a law, but rather a summary of physical conditions within given limits.

[2] Belli's formula for sea-level pressures

$$e = e' - 0{\cdot}592\,(t - t')$$

is easy to remember, but of course wants a table of vapour-tensions.

[3] This is evidently equivalent to

$$B\,(t/4) = 100.$$

Substituting this value of B in the formula (2), and putting for A the observed ratio of the temperatures, we have

$$(50/70)(5{\cdot}7)(70 - 50) = 100 - H$$
whence $H = 19$.[1]

This value of H is the same as Marvin gives for the same temperatures when the barometer is at 30 inches. For a barometric pressure of 26 inches the relative humidity would be 23 per cent. It would not perhaps be very difficult, albeit under the circumstances scarcely worth while, to introduce a barometric factor into the equation (2). That the results agree so well with those obtained by means of the psychrometric formula seems to suggest a further illustration of the important part the diffusion of vapour plays in the theory of the wet-bulb.[2]

It follows from the quadratic form of the equation (2) that when t and B are given there are two values of t' for every value of H. For the solution of the equation is

$$t' = \frac{t}{2} \pm \sqrt{\frac{Bt^2 - 4(100 - H)t}{4B}}.$$

The negative sign, however, gives values of the wet-bulb less than half the dry-bulb which, so far as I know, have never been observed. It is perhaps worth notice that Ferrel's formula, *i.e.*

$$f = f_1 - AB(t - t_1)(1 + Ct_1) \quad \ldots\ldots \quad (3)$$

also gives quadratic values of the wet-bulb temperature.

The Kenilworth (Kimberley) dew-points and relative humidities, as published in the Annual Reports of the Cape Meteorological Commission, have been computed for each hour from the simultaneous readings of the dry- and wet-bulbs by means of the Glaisher Factors. I say Glaisher Factors instead of Glaisher Tables because the latter are not extensive enough for ordinary use in South Africa; indeed for high temperatures, say between 90° and 100°, it is the exception rather than the rule to find the observed readings of the wet-bulb within the range of the Tables. The Tables were therefore extended by extrapolation to include wet-bulb temperatures some 10° to 15° lower than Glaisher gives. The choice of these Tables was determined in the first place by two principal reasons: one that the factors purport to be derived from actual experiment under average atmospheric conditions, the other that their arrangement is by far the most convenient of any yet published.[3] The first consideration was of some moment in view of the fact that there are not means at Kenil-

[1] For the same temperatures Glaisher gives 27 per cent. Of course B is rather less, so that the true value of H is greater than that found above.

[2] A formula such as (2) above, in which the complement of the relative humidity appears, would have advantages from a physical point of view over the various psychrometric formulæ, which recognise only the vapour-tensions. For suppose it to be

$$ABkP(t - t') = 100 - H.$$

Then for any given value of t and H, t' will rise as P increases. Also when t and t' are given H will increase as P decreases. The formula does not fail for very large or very small values of P.

[3] My own MS. Tables are arranged exactly like Glaisher's. They give in parallel columns, for any assigned dry-bulb, the wet-bulb temperatures for each whole degree in descending order of magnitude, the dew-points and relative humidities, with the respective differences for an increase of 1° in the dry-bulb, computed (1) from the Glaisher Factors, and (2) from Ferrel's formula and a pressure of 26 inches.

worth for creating a forced draught over the thermometers at all hours. Hazen has claimed that his Tables, computed by means of a psychrometric formula very similar to Ferrel's, and which agree very well with Marvin's, "will be but slightly in error for all shelters of fair exposure."[1] My own observations, however, do not altogether corroborate this view. For with a given vapour-tension the wet-bulb will read much higher in a light wind than in a gale; and however accurate our Tables may be they cannot furnish correct results in individual cases unless the wet-bulb be reduced to some fixed standard of wind velocity. This remark applies of course as much to Glaisher's Tables as to any others, but, so far as I have been able to examine the question, when an unaspirated wet-bulb is used, results by the former are just as likely to be nearly correct as results by the latter. In Jelinek's elaborate *Psychrometer-Tafeln* this difficulty has been given full recognition by computing vapour-tensions and humidity ratios for moderate winds, adding corrections for light and strong winds respectively.[2] These Tables are highly spoken of and, on the Continent, extensively used. Personally I have not found them convenient for use on the South African Tableland; nor does it seem certain that the given corrections could be altogether justified, on general principles, where climates are very arid. Moreover, it seems to me that the corrections are made at the wrong end of the operation.

With all deference to so great an authority, would it not be better that the readings of an unaspirated wet-bulb should be corrected for wind velocity at the same time as the instrumental errors are allowed for, and that the dew-point, vapour-tension, and relative humidity should be then taken out of Tables constructed expressly for use with a sling, or aspirated, thermometer? With this idea, and as a tentative experiment, I have within the past few years accumulated between 2000 and 3000 observations intended to indicate the error of the wet-bulb in air currents of different velocities. The method of procedure was as follows:—At such times as the temperature of the air was changing slowly, chiefly in the afternoon and late at night, the unaspirated dry- and wet-bulbs were read. They were then vigorously fanned until the wet-bulb had fallen to a stationary temperature. This fall (which occasionally was as much as 2½°) was noted, together with the velocity of the wind 40 ft. above the ground for the half hour preceding the observation. Finally the results were collected, averaged, and smoothed, also gaps were filled up by a rough interpolation, and a summary made, as Table I., giving approximate corrections to be subtracted from the readings of the wet-bulb for a given wind velocity and depression of the wet-bulb. Occasionally the dry-bulb was observed to rise during the fanning process while the wet-bulb was falling. When this happened the observed fall of the wet-bulb was augmented by half the rise of the dry-bulb. Table I. is to be regarded as provisional, and may have to be somewhat modified, particularly for large depressions of the wet-bulb, by a more extended series of observations. Meanwhile it ought to answer fairly well for all stations on the South African Tableland. Such Tables, made accurate by sufficiently numerous observations, and constructed for bulbs of different sizes and shapes under different

[1] H. A. Hazen, *Handbook of Meteorological Tables*, 1888, p. 57.

[2] *Jelinek's Psychrometer-Tafeln erweitert und vermehrt von J. Hann, etc.*, Fifth Ed., 1903.

TABLE I.—Corrections to be applied to the Readings of the Wet-Bulb Thermometer, for Wind Velocity at an Altitude of 40 Feet.

Depression of the Wet-Bulb.	Velocity of the Wind in Miles per Hour.																
$t-t'$	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15 to 20	20 and over
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
1	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
2	0·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
3	0·2	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
4	0·3	0·2	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0	0·0
5	0·4	0·3	0·3	0·3	0·3	0·2	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0	0·0
6	0·5	0·4	0·4	0·3	0·3	0·3	0·1	0·1	0·1	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0
7	0·6	0·5	0·5	0·4	0·4	0·4	0·2	0·2	0·2	0·1	0·1	0·1	0·0	0·0	0·0	0·0	0·0
8	0·7	0·6	0·6	0·5	0·5	0·5	0·3	0·2	0·2	0·2	0·2	0·2	0·0	0·0	0·0	0·0	0·0
9	0·9	0·7	0·7	0·6	0·5	0·5	0·4	0·3	0·3	0·2	0·2	0·2	0·1	0·1	0·0	0·0	0·0
10	1·0	0·8	0·8	0·7	0·6	0·5	0·4	0·4	0·4	0·3	0·3	0·3	0·1	0·1	0·1	0·0	0·0
11	1·1	0·9	0·8	0·8	0·7	0·6	0·5	0·5	0·5	0·3	0·3	0·3	0·1	0·1	0·1	0·1	0·0
12	1·2	1·0	0·9	0·9	0·8	0·6	0·6	0·6	0·6	0·4	0·4	0·4	0·1	0·1	0·1	0·1	0·0
13	1·3	1·1	1·0	0·9	0·8	0·7	0·7	0·6	0·6	0·4	0·4	0·4	0·2	0·2	0·2	0·1	0·0
14	1·4	1·1	1·0	1·0	0·9	0·8	0·8	0·7	0·7	0·5	0·5	0·4	0·2	0·2	0·2	0·2	0·0
15	1·5	1·2	1·1	1·1	1·0	1·0	1·0	0·9	0·7	0·5	0·5	0·5	0·3	0·3	0·2	0·2	0·0
16	1·7	1·3	1·2	1·2	1·2	1·1	1·1	0·9	0·8	0·6	0·6	0·5	0·3	0·3	0·3	0·2	0·0
17	1·8	1·4	1·2	1·2	1·2	1·2	1·1	1·0	0·8	0·7	0·6	0·5	0·4	0·4	0·3	0·2	0·0
18	1·9	1·5	1·3	1·3	1·3	1·3	1·2	1·0	0·8	0·7	0·7	0·6	0·4	0·4	0·4	0·2	0·0
19	2·0	1·6	1·3	1·3	1·3	1·4	1·2	1·0	0·9	0·8	0·7	0·6	0·5	0·5	0·4	0·3	0·0
20	2·1	1·7	1·4	1·3	1·3	1·4	1·3	1·1	0·9	0·9	0·8	0·6	0·5	0·5	0·4	0·3	0·0
21	2·2	1·8	1·5	1·4	1·4	1·4	1·3	1·1	1·0	0·9	0·8	0·6	0·6	0·6	0·5	0·3	0·0
22	2·3	1·9	1·6	1·5	1·5	1·4	1·4	1·2	1·0	1·0	0·9	0·7	0·6	0·6	0·5	0·3	0·0
23	2·4	2·0	1·7	1·6	1·5	1·5	1·4	1·3	1·1	1·0	0·9	0·7	0·7	0·7	0·5	0·3	0·0
24	...	2·1	1·8	1·6	1·6	1·5	1·5	1·4	1·2	1·1	0·9	0·8	0·7	0·7	0·6	0·3	0·0
25	...	...	1·9	1·7	1·6	1·6	1·5	1·4	1·3	1·1	1·0	0·8	0·8	0·8	0·6	0·3	0·0
26	...	...	...	...	1·7	1·6	1·6	1·5	1·4	1·2	1·0	0·9	0·8	0·8	0·6	0·3	0·0
27	...	...	...	...	1·8	1·7	1·6	1·6	1·5	1·3	1·0	0·9	0·9	0·9	0·6	0·3	0·0
28	...	...	...	...	...	1·7	1·7	1·7	1·6	1·3	1·1	1·0	0·9	0·9	0·7	0·4	0·0
29	...	...	...	...	...	...	1·7	1·7	1·7	1·4	1·1	1·0	1·0	1·0	0·7	0·4	0·0
30	...	...	...	...	...	...	...	1·9	1·8	1·5	1·2	1·1	1·0	1·0	0·8	0·4	0·0
31	...	...	...	...	...	...	...	...	1·9	1·6	1·3	1·1	1·1	1·0	0·8	0·4	0·0
32	...	...	...	...	...	...	...	...	...	...	1·4	1·2	1·1	1·0	0·8	0·4	0·0

atmospheric pressures, ought to add something to our knowledge of the physical properties of the wet-bulb thermometer.

After all there is not so much difference as one might expect between the monthly means of the hourly values of dew-point and humidity, computed respectively by means of the Greenwich Factors from the uncorrected wet-bulb, and by Ferrel's psychrometic formula, after correcting the wet-bulb for wind velocity. In March 1904, the most humid month of that year, the mean dew-point according to Glaisher's method

TABLE II.—Hourly Means of the Hourly Values of Dew-Point and Humidity.

1904.	Dew-Point.				Humidity.			
	March.		November.		March.		November.	
Hour.	Glaisher.	Ferrel.	Glaisher.	Ferrel.	Glaisher.	Ferrel.	Glaisher.	Ferrel.
	°	°	°	°	%	%	%	%
Midnight	55·3	55·9	41·7	39·3	79·0	80·8	47·3	44·2
1 a.m.	55·1	55·5	41·7	39·8	80·2	81·5	50·4	47·9
2 ,,	54·6	55·3	41·8	40·1	80·3	81·8	53·7	51·3
3 ,,	54·6	55·2	42·1	40·6	81·6	83·2	55·8	53·8
4 ,,	54·6	55·2	41·4	40·0	82·3	83·8	56·1	53·9
5 ,,	54·6	55·0	41·5	40·4	84·5	85·7	57·7	55·8
6 ,,	54·9	55·4	44·9	44·2	87·2	88·6	58·7	57·8
7 ,,	55·7	56·3	46·4	45·2	84·4	85·8	49·6	48·6
8 ,,	56·2	57·1	46·2	44·3	71·7	74·0	41·0	39·5
9 ,,	55·9	56·9	45·6	42·9	61·1	63·9	35·0	33·0
10 ,,	56·0	56·8	44·9	41·2	55·9	58·2	30·7	28·1
11 ,,	54·9	55·5	44·0	39·4	50·3	51·7	27·3	23·9
Noon	54·4	54·8	43·5	38·3	45·6	46·9	25·6	22·0
1 p.m.	53·8	54·0	43·3	37·6	43·7	44·6	26·1	22·3
2 ,,	53·5	53·3	43·5	37·1	43·5	44·1	27·7	23·9
3 ,,	53·0	52·7	42·5	35·5	42·8	43·2	26·4	22·1
4 ,,	53·2	53·0	42·1	34·6	44·5	45·2	25·7	21·3
5 ,,	53·7	53·9	42·1	35·5	48·8	49·8	26·7	22·4
6 ,,	54·8	55·7	42·4	36·9	57·4	58·8	29·8	25·6
7 ,,	55·6	56·3	43·2	39·5	64·3	66·5	35·2	31·8
8 ,,	55·6	56·2	42·0	37·9	68·2	70·0	36·6	32·7
9 ,,	55·9	56·6	41·8	38·0	72·6	74·5	39·2	35·7
10 ,,	56·0	56·7	42·1	39·2	75·6	77·4	42·7	39·4
11 ,,	56·0	56·6	42·0	39·2	77·6	79·4	45·6	42·3
Mean	54·9	55·4	43·0	39·4	66·0	67·5	39·6	36·6

was 54°·9, and the relative humidity 66 per cent; by Ferrel's formula the same elements were 55°·4 and 67·5 per cent. In November 1904, the driest month of that year, we get by Glaisher's method a dew-point of 43°·0 and a relative humidity of 39·6 per cent; Ferrel's formula giving 39°·4 and 36·6 per cent. The diurnal curves computed by either method have much the same characteristics; the Ferrel curves, however, have the greater range, as will be seen in Table II. Table III. shows that in March, fairly high dew-points being the rule, the differences in the daily means of dew-point scarcely ever exceed 1°, nor are the humidity differences ever greater than 3 per cent. In November, on the other hand, the same respective differences are occasionally as much as 9° and 8 per cent.

Taking the individual hourly temperatures of the dew-point, the computed minima and maxima are :—

	March.	November.
Glaisher	41°·2 to 66°·1	26°·2 to 61°·3
Ferrel	35·3 to 67·1	11·7 to 61·6

Also the humidity ratios are :—

	March.	November.
	% %	% %
Glaisher	25 to 99	14 to 100
Ferrel	22 to 99	6 to 100

Since March and November 1904 represent opposite extremes of humid condition at Kimberley, we may take it that these differences are the greatest likely to be met with in general.

TABLE III.—Daily Means of the Hourly Values of Dew-Point and Humidity.

1904.	Dew-Point.				Humidity.			
	March.		November.		March.		November.	
Date.	Glaisher.	Ferrel.	Glaisher.	Ferrel.	Glaisher.	Ferrel.	Glaisher.	Ferrel.
	°	°	°	°	%	%	%	%
1	46·2	45·9	39·4	35·9	51·1	51·2	31·6	28·1
2	50·3	50·6	36·4	33·2	57·0	58·5	41·7	37·4
3	51·3	51·3	36·6	32·1	56·2	56·8	38·1	33·2
4	57·2	58·2	41·6	38·8	67·8	70·2	44·4	41·5
5	60·3	61·4	39·7	34·7	77·4	80·3	36·1	31·3
6	58·7	59·8	38·5	29·9	76·7	79·6	29·3	22·8
7	60·1	61·0	39·0	30·6	81·4	83·5	26·3	20·1
8	60·6	61·5	40·8	33·4	74·3	76·4	28·0	22·4
9	58·8	60·0	42·8	39·1	70·8	73·8	28·4	25·3
10	62·8	63·5	45·9	43·4	85·8	87·9	32·5	30·4
11	61·8	62·3	44·8	42·4	84·8	86·2	30·6	28·5
12	61·9	62·6	42·4	38·9	82·3	84·1	27·7	25·0
13	59·5	60·5	43·4	41·6	75·6	78·0	52·4	50·6
14	58·7	59·8	33·7	26·9	74·9	77·6	34·2	27·3
15	54·3	54·1	46·8	45·4	64·2	64·5	51·0	49·5
16	47·8	46·6	51·4	51·7	53·8	53·2	55·1	56·2
17	53·9	54·5	44·2	41·4	62·0	63·5	39·4	37·5
18	54·7	55·1	39·3	32·8	66·7	67·8	33·1	28·4
19	56·0	57·1	55·1	56·0	65·3	67·9	72·4	74·8
20	53·2	53·8	44·8	40·5	59·6	60·9	52·3	49·0
21	49·8	49·7	45·7	44·9	54·1	54·4	38·1	37·8
22	48·7	48·6	40·9	36·9	54·7	55·3	34·3	30·1
23	53·2	53·8	34·1	25·3	60·1	61·2	29·3	31·3
24	53·1	53·9	37·2	30·3	60·1	62·0	29·1	22·7
25	52·7	53·3	53·9	55·1	59·9	61·2	58·7	61·4
26	50·8	50·5	56·6	57·8	56·8	57·0	66·5	69·3
27	50·8	50·7	48·4	46·1	49·2	50·0	46·8	45·5
28	55·5	56·3	40·3	36·3	70·7	73·0	39·9	29·8
29	55·9	56·7	41·4	36·2	71·5	73·6	31·6	27·1
30	51·8	52·0	46·3	45·3	59·9	60·5	35·2	34·5
31	52·2	52·6	...	...	60·0	61·0	...	...

It is usual in places where only monthly averages are wanted to compute the average dew-point and relative humidity from the monthly averages of the dry- and wet-bulb temperatures, instead of computing the

same elements for each observation and averaging the results. In Tables IV. and V. this has been done for

1. The unaspirated, uncorrected wet-bulb, by means of Glaisher's factors.
2. The wet-bulb, corrected for wind velocity by Table I. by means of the same factors.
3. The wet-bulb, corrected for wind velocity by Table I. by means of Ferrel's formula.

A comparison between the corresponding columns of Tables II., IV., V. will show how close an approximation to the truth may be expected to issue from the operation of deducing the dew-point and relative humidity from the monthly averages of dry- and wet-bulb temperatures. It is evident that both in March and November Glaisher's method gives almost exactly the same dew-point, whether it be deduced from the

TABLE IV.—Hygrometer Averages, March 1904.

Hour.	Wind Velocity.	Dry-Bulb.	Wet-Bulb.	$t-t'$.	Corrected Wet-Bulb.	Dew-Point.[1]	Dew-Point.[2]	Relative Humidity.[1]	Relative Humidity.[2]	Dew-Point.[3]	Relative Humidity.[3]
	Miles per Hour.	°	°	°	°	°	°	%	%	°	%
Midnight	3	62·3	58·5	4	58·3	55·3	54·9	78	77	56·0	80
1 a.m.	2	61·5	58·1	3	58·0	55·2	55·0	80	80	56·0	83
2 ,,	2	61·0	57·6	3	57·5	54·6	54·5	80	80	55·4	82
3 ,,	2	60·6	57·4	3	57·3	54·6	54·5	81	81	55·3	83
4 ,,	2	60·3	57·2	3	57·1	54·5	54·3	82	81	55·2	83
5 ,,	2	59·4	56·8	3	56·7	54·5	54·3	84	84	55·1	86
6 ,,	2	58·9	56·8	2	56·8	54·9	54·9	87	87	55·5	88
7 ,,	2	60·7	58·0	3	57·9	55·6	55·5	84	84	56·3	87
8 ,,	4	65·9	60·6	5	60·3	56·3	55·7	72	71	57·3	74
9 ,,	5	70·3	62·1	8	61·6	55·8	54·9	60	58	56·9	63
10 ,,	5	73·4	63·3	10	62·8	55·9	55·0	54	52	57·3	57
11 ,,	5	75·7	63·5	12	62·9	54·8	53·8	48	47	56·0	51
Noon	5	78·0	64·0	14	63·2	54·3	52·9	44	42	55·3	47
1 p.m.	5	79·0	64·1	15	63·1	53·9	52·2	41	39	54·5	43
2 ,,	5	79·1	63·9	15	62·9	53·5	51·8	41	39	54·1	43
3 ,,	5	79·3	63·7	16	62·6	53·0	51·1	41	38	53·3	41
4 ,,	5	78·3	63·4	15	62·4	53·1	51·4	42	39	53·5	43
5 ,,	4	75·8	62·8	13	62·0	53·6	52·1	47	44	54·3	48
6 ,,	4	72·0	62·3	10	61·7	55·0	54·1	55	53	56·2	57
7 ,,	3	68·8	61·4	7	61·0	55·7	54·9	62	61	56·8	66
8 ,,	3	67·1	60·7	6	60·4	55·6	55·1	66	65	56·8	70
9 ,,	3	65·5	60·2	5	59·9	55·9	55·3	72	71	56·8	74
10 ,,	3	64·3	59·8	4	59·6	56·1	55·7	75	74	57·0	77
11 ,,	3	63·5	59·4	4	59·2	56·0	55·6	76	75	56·8	78
Means	4	68·4	60·6	8	60·1	54·9	54·1	64·7	63·4	55·7	66·8

[1] From uncorrected Wet-Bulb and Greenwich Factors.
[2] From Wet-Bulb, corrected for Wind Velocity, and Greenwich Factors.
[3] From Wet-Bulb, corrected for Wind Velocity, and Ferrel's Formula.

monthly means of the dry- and wet-bulbs or from the average of all the dew-points. And the same is true of the monthly averages for any hour of the day. But the humidity ratios average anything from one to four per cent lower by the former method, the greatest differences appearing in the drier month. When Ferrel's formula is used, the average of all the dew-points is rather less than the dew-point computed from the

monthly means of dew-point, particularly in November, while the humidity ratios are greater. We may summarise the results as follows, calling the averages of all the dew-points or relative humidities the true means :—

	Ferrel		Glaisher.	
	Mar.	Nov.	Mar.	Nov.
True Mean Dew-Point . . .	55°·4	39°·4	54°·9	43°·0
Approximate Dew-Point . .	55·7	40·6	54·9	43·0
	%	%	%	%
True Mean Humidity . . .	68	37	66	40
Approximate Humidity . .	67	35	65	37

By Glaisher (aspirated wet-bulb) :—

Approximate Mean Dew-Point . .	54°·1	41°·4
,, ,, Humidity . .	63%	35%

The maximum difference between the corresponding Ferrel and Glaisher dew-points computed from the monthly means of dry- and wet-bulbs, the wet-bulb being corrected in both cases for wind velocity, is $3\frac{1}{2}°$, while the maximum difference between the corresponding ratios of humidity is 5 per cent.

TABLE V.—Hygrometer Averages, November 1904.

Hour.	Wind Velocity.	Dry-Bulb.	Wet-Bulb.	$t-t'$.	Corrected Wet-Bulb.	Dew-Point.[1]	Dew-Point.[2]	Humidity.[1]	Humidity.[2]	Dew-Point.[3]	Humidity.[3]
	Miles per Hour.	°	°	°	°	°	°	%	%	°	%
Midnight	5	63·5	51·6	12	51·0	41·6	40·6	45	43	40·7	43
1 a.m.	4	61·6	50·9	11	50·2	41·7	40·4	48	46	40·6	46
2 ,,	4	60·0	50·3	10	49·7	41·8	40·6	51	49	41·1	50
3 ,,	4	59·2	50·1	9	49·6	42·0	41·1	53	51	41·6	52
4 ,,	3	58·2	49·4	9	48·8	41·5	40·4	54	51	40·8	52
5 ,,	3	57·4	49·1	8	48·6	41·5	40·8	56	54	41·1	54
6 ,,	5	60·3	52·1	8	51·6	44·9	44·0	57	55	44·9	57
7 ,,	7	67·2	55·6	12	55·0	46·3	45·1	47	45	46·4	48
8 ,,	7	72·8	57·5	15	56·6	46·2	44·6	39	36	45·2	38
9 ,,	8	76·8	58·5	18	57·7	45·7	44·3	33	32	44·4	32
10 ,,	8	79·9	59·0	21	58·0	44·7	43·0	29	27	42·4	26
11 ,,	8	82·3	59·3	23	58·2	43·9	42·0	26	25	40·6	23
Noon	8	84·1	59·6	24	58·4	43·5	41·4	24	22	39·2	21
1 p.m.	9	84·3	59·5	25	58·4	43·2	41·3	24	22	39·0	20
2 ,,	9	84·3	59·5	25	58·4	43·2	41·3	24	22	39·0	20
3 ,,	9	85·1	59·4	26	58·2	42·6	40·6	23	21	37·5	19
4 ,,	9	84·5	58·8	26	57·6	41·9	39·9	22	21	36·3	18
5 ,,	8	82·7	58·2	25	56·9	41·8	39·6	25	22	36·0	19
6 ,,	7	79·1	57·3	22	56·1	42·3	40·2	27	25	38·0	23
7 ,,	6	74·5	56·3	18	55·1	43·1	41·0	33	30	40·0	29
8 ,,	6	71·8	54·7	17	53·6	41·8	39·9	34	32	38·8	30
9 ,,	6	69·4	53·7	16	52·6	41·5	39·5	36	33	38·6	33
10 ,,	5	67·0	53·1	14	52·3	42·0	40·5	40	38	40·4	38
11 ,,	5	65·1	52·4	13	51·7	42·0	40·7	43	41	40·8	41
Means	6	72·1	55·2	17	54·3	43·0	41·4	37	35	40·6	35

[1] From uncorrected Wet-Bulb, by Greenwich Factors.
[2] From Wet-Bulb, corrected for Wind Velocity, and Greenwich Factors.
[3] From Wet-Bulb, corrected for Wind Velocity, and Ferrel's Formula.

The want of agreement between the dew-points obtained by the two methods when the depression of the wet-bulb is considerable will appear the more remarkable if it be remembered that Glaisher's factors "have been found from the combination of many thousand simultaneous observations of the dry- and wet-bulb thermometers and of Daniell's Hygrometer, taken at the Royal Observatory, Greenwich, . . . from observations taken at high temperatures in India, and others at low and medium temperatures at Toronto. The results at the same temperatures were found to be alike at these different places." Blanford, however, seems

TABLE VI.—A Comparison between some Direct Observations of Dew-Point made by Blanford in India and the Computed Values.

Dry-Bulb.	Wet-Bulb.	Dew-Point.				
		Regnault's Hygrometer.	Glaisher's Factors, 1.	Ferrel's Formula, 1.	Glaisher's Factors, 2.	Ferrel's Formula, 2.
°	°	°	°	°	°	°
92·4	67·9	47·7	53	54	50	50
93·4	70·1	52·4	56	57	54	54
94·8	70·6	50·8	56	57	54	54
94·0	69·7	53·3	55	56	53	53
82·9	62·3	40·0	49	47	46	45
96·4	68·5	46·8	52	52	50	50

not to have shared in this conclusion,[1] for according to a series of observations he made in 1876, or earlier, Glaisher's factors gave average results much too high.[2] It is not unlikely, nevertheless, that in every case Blanford may have done what he suspected possible, what less experienced observers frequently do, and what Crova showed may be anticipated with Regnault's Hygrometer, namely, read the dew-point too low. Table VI. is constructed to illustrate this. Of the hygrometer, and dry- and wet-bulb observations made by Blanford, it contains those in which the difference between the Glaisher and Regnault dew-points was most pronounced, and in which the depression of the wet-bulb was greatest. In this Table, column 1 gives the observed mean temperature of the air, column 2 the wet-bulb, column 3 the observed dew-point by Regnault's Hygrometer. In columns 4 and 5 I have added the tabular dew-points obtained by means of Glaisher's factors and Ferrel's formula respectively. Since in these particular selected observations the wet-bulb was not in a forced draught, columns 6 and 7 have been computed on the assumption that the velocity of the wind at 40 feet above the ground was five miles an hour; or, in other words, that the wet-bulb readings were about 1°·5 too high. Even then these two columns, which agree quite well, are higher than the Regnault numbers. In fact, if the latter are correct, we should have to assume that the exposure of the dry- and wet-bulbs was so bad that its readings were fully 3° too high, which is probably too great to justify adverse criticism of Glaisher's factors.

[1] And even at Toronto Glaisher's Tables seem not to be in use, to judge from the Annual Reports of the Meteorological Service.

[2] See W. N. Shaw, *Report on Hygrometric Methods*, p. 135. *Phil. Trans.* vol. clxxix. 1888. I have not access to Blanford's original paper.

Taking all together, then, the facts seem to indicate that even if Glaisher was as much in error at low temperatures as good critics assert, he had at any rate something to go upon in proposing his factors.[1]

Note.—A comparison has been made between the humidity values of Table II. and those derived from a Richard recording hair hygrometer. Excepting in a rough way, there is not much resemblance between them. But after reducing the curves to give the same daily range, it appears that in November the hygrometer curve of relative humidity lags to some extent behind the Ferrel curve, and still more behind the Glaisher curve. In March, however, while the hygrometer curve and the Glaisher curve never disagree by more than 2 per cent, excepting at two separate hours, the former and the Ferrel curve differ rather irregularly by anything up to 4 per cent.

Rainfall Map of Africa.

At the Meeting of the British Association on September 1, 1905, Dr. A. J. Herbertson and Mr. P. C. Waite communicated a paper on a "New Rainfall Map of Africa," of which the following is an abstract:—

Two years ago, when preparing the *Atlas of Meteorology* in conjunction with Mr. Bartholomew, one of us found it necessary to make a new rainfall map of the world. In Africa the necessary data were almost non-existent outside Cape Colony and Algeria, except for a year or two at some coast stations, and at those being started under the auspices of a British Association Committee and those of German colonies. At these stations ten more years of observations have since accumulated, and a large number of new stations have been started, which enable us to give a somewhat more reliable map of the rainfall of the continent. In the present map the shorter period observations have been utilised, when others did not exist, in order to determine the outs and ins of the rainfall lines, but wherever possible the final position of the lines has been adjusted to the values of the stations with longest means. Even then, no one can be more conscious than the authors of the imperfections of the map. In it the dotted lines indicate the lines based on other than direct measurement of rainfall. The continuous lines may be taken as showing roughly the main characteristics of African rainfall, while the dotted lines are surmises based on travellers' accounts of rainfall and vegetation.

The scale of the map is small, and for this reason many minor details indicated even by the existing figures are omitted. While the map is only a first approximation to a summary of the distribution of rainfall in Africa, it shows clearly a number of points of great geographical interest.

While the general distribution is similar to that in other maps, we have been able to draw a number of lines with greater precision and to revise the mapping of certain areas. For instance, the newer data enable us to join up the Central African heavy-rain area with Abyssinia, a point not before settled. Again, a number of observations close to the edge of the Drakenberg escarpment, though still for a very short period, enable us at least to conclude that the upper part of the Drakenberg is wetter than the hilly land of the terraces of Natal, and

[1] "I think Mr. Glaisher did wisely in constructing his table of factors"; J. D. Everett, *Q.J.R.Met.Soc.*, January 1892. Glaisher "determined a series of factors, by which the depression of the dew-point may be directly computed from the depression of the wet-bulb (although with no great degree of accuracy)"; C. Abbe, *Met. Apparatus and Methods*, 1888, p. 367. See also, by the same author, article "Meteorology," *Ency. Brit.* vol. xxx. 1902, p. 701; *M.W.R.*, January 1900, p. 14.

that in all probability this is due to the scarped edge of the tableland farther north. One doubtful matter, of great importance to South Africa, cannot be settled, and that is the bending of the rainfall lines along the eastern margin of the Kalahari Desert. If there were only as great a number of rain-gauges in Bechuanaland as there are in German South-West Africa, this important matter would be settled, at least in a rough way, in another decade. These are essential also if we are to discover whether there is any permanent drying up, or whether, as is more probable, there is a succession of drier and wetter periods.

The heaviest rainfall of all occurs round the Kamerun Mountains, where one station, Debunja, has an annual precipitation of 10,454 mm., *i.e.* roughly 400 inches—not much less than that of Cherrapunji in the Khasi Hills of India—so that Africa has thus the second heaviest rainfall station known. In 1902, at this station, the enormous rainfall of 14,133 mm., *i.e.* about 560 inches, was recorded. At the other end of the scale there are such places as Walfisch Bay and Suez with less than one inch of rain, and parts of the desert which are probably drier still—one heavy thunderstorm falling in a decade or two.

Looking at the map as a whole, the striking features are (1) the belt of wet climate round the equator, broken by a drier area near, but not touching, the east coast; (2) the dry belts round the tropics, which do not extend quite to the east coast in the south; (3) the wet south-west and north-west corners; (4) the continuous wet area of varying width which fringes the east coast from Cape Colony to the equator.

In order to apply the data of such a map to a particular region, it is necessary to take into account the local configuration. On the High Veldt here this should not be difficult, for the land forms are few and of simple types. A few rain-gauges properly distributed on and round each type of kopje should, in a few years' time, yield invaluable information on the distribution of rainfall on and round each land form. Then, using the average shown on the general map, it will be possible to say—on this side or exposure the precipitation will be so much above or below the average.

The map, for economic purposes, requires to be supplemented by several others. Thus, it is not only the total annual precipitation which is of importance: the time of year at which it falls, and the nature of the fall at each season, have also much bearing on vegetation and cultivation. Such a map shows that places having the same annual rainfall may yet have very different climates, on account of the different periods of the year at which the fall takes place. Again, maps showing evaporation and run-off are also required, in addition to good topographical ones, before the rainfall can be said to be fully investigated. For much of South Africa the information upon which such map might be based does not yet exist.

A RAPID METHOD OF FINDING THE ELASTIC FORCE OF AQUEOUS VAPOUR AND THE RELATIVE HUMIDITY FROM DRY-BULB AND WET-BULB THERMOMETER READINGS.[1]

By JOHN BALL, Ph.D., B.Sc., Assoc.M.Inst.C.E.

[Read December 20, 1905.]

In the course of some investigations on atmospheric humidity, the author has been led to devise a simple and rapid method of finding the elastic

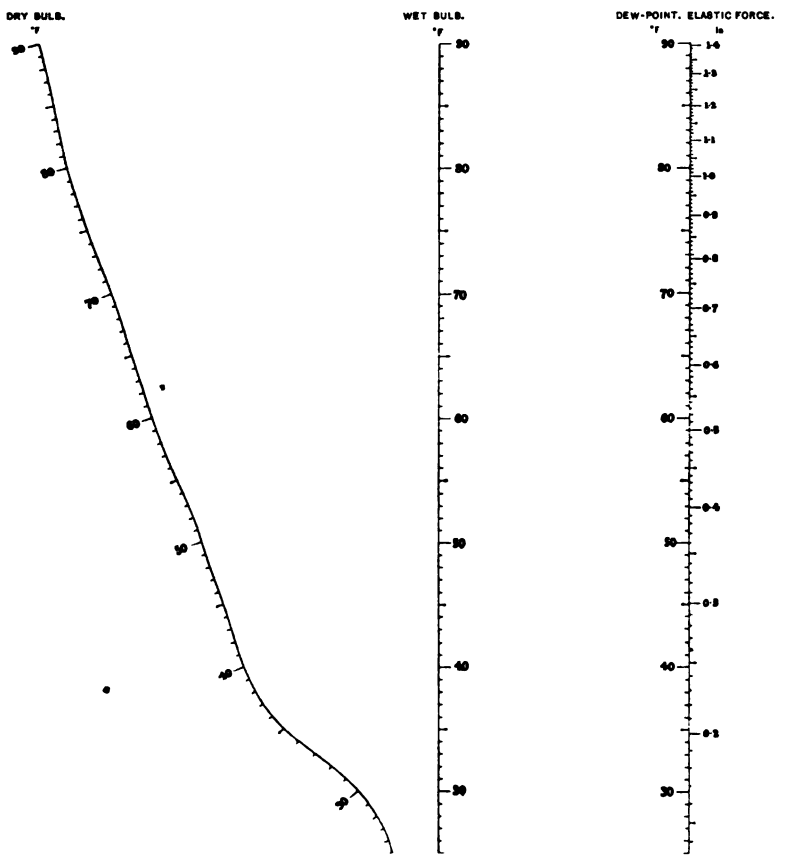

Fig. 1.—Calculator for Dew-Point and Elastic Force of Aqueous Vapour.

force of aqueous vapour[2] and the relative humidity of the air on the basis of the well-known formulæ of Glaisher. The essential feature of

[1] Communicated by permission of Capt. H. G. Lyons, Director-General of the Survey Department, Ministry of Finance, Egypt.

[2] I have adhered to Glaisher's terminology; "vapour tension," or preferably "vapour pressure," would be a better term than "elastic force of aqueous vapour," but the old nomenclature has become familiar by long usage.

the method is the use of a special form of diagram in place of the ordinary tables.

In the calculator for dew-point and elastic force in Fig. 1 there are four scales, representing respectively dry-bulb thermometer readings, wet-bulb thermometer readings, dew-points, and elastic forces, the last two scales being arranged along a single line. These scales are so placed and graduated that if a straight-edge be laid across the diagram so as to

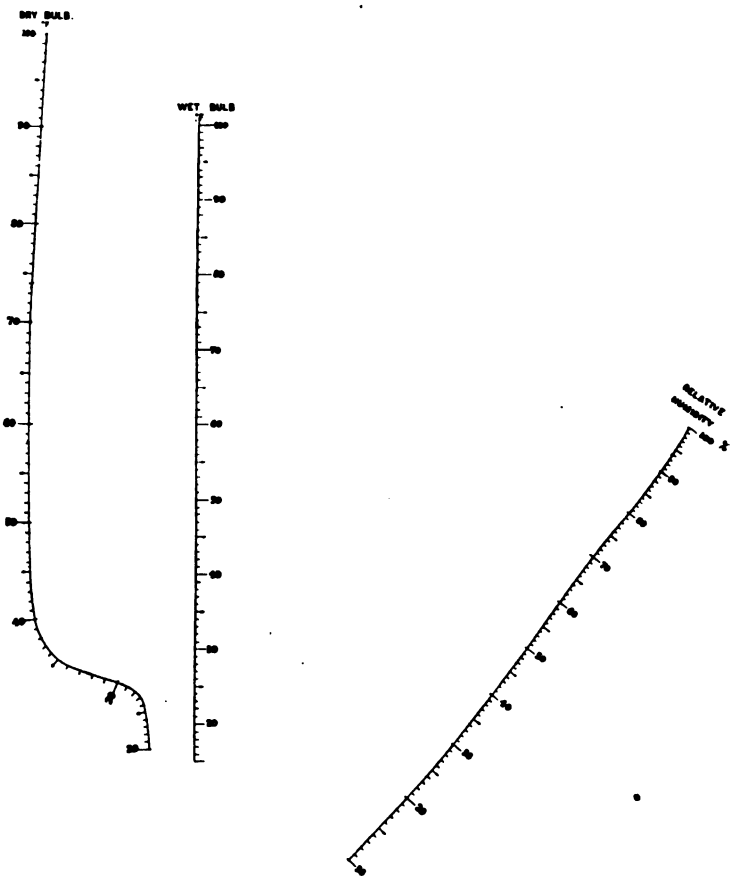

FIG. 2.—Relative Humidity Calculator.

pass through any given dry-bulb and wet-bulb readings on their respective scales, the dew-point and elastic force of aqueous vapour will be at once given by the point where the straight-edge cuts the remaining double scale.

Similarly in the humidity-calculator in Fig. 2, the relative humidity can be at once read off by aligning a straight-edge through any given dry-bulb and wet-bulb readings.

The figures are considerably reduced from the original diagrams, but they will be found large enough to enable the method to be tested. If

the diagrams be redrawn on the original scale (about double that of the figures) by the method given below, they will be found to yield results of about the same accuracy as the usual tables, whilst presenting some advantages over the latter. The calculation being made directly from the thermometer readings themselves, it is unnecessary to take out their difference; no interpolation is required in any case; the elastic force is obtained without the necessity of first calculating the dew-point; and the whole range is presented at one view instead of on several pages. Further, it may be noticed that the graduations on the enlarged diagrams will be of about the same degree of openness as those on the instruments themselves, so that the degree of accuracy of the result will be equal to that of the readings, and the effects on the result produced by small variations in the observed data can be readily studied.

The diagrams open up a simple means of applying Glaisher's results to the centigrade system. For it is easy to regraduate the temperature scales in centigrade degrees, and the elastic force scale in millimetres, leaving the positions of the scales unchanged; and the hygrometric state of the air can then be directly read off without any conversion from one system to the other. The humidity scale is of course the same in both systems.

In practice it will be found convenient to draw the diagrams on a stout card to avoid any distortion by the unequal shrinkage to which ordinary paper is liable. A strip of transparent celluloid, bearing a straight line scratched on its under surface, is an improvement on the ordinary wooden straight-edge in making the alignment.

Theory of the Dew-point and Elastic Force Calculator.

Let a number of equidistant horizontal lines (Fig. 3) be drawn, each of the equal intervals between them representing 1° of temperature. Let AB and CD be two vertical lines cutting the horizontal ones, and called the dew-point scale

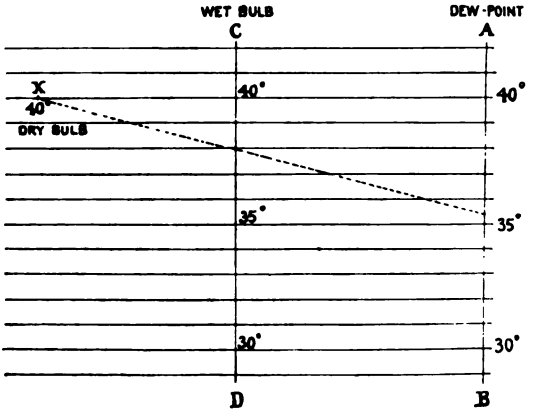

FIG. 3.

and wet-bulb scale respectively. Considering now the 40° horizontal line, it is clear that if we take a point X on it such that the distances of X from AB and

CD are in the ratio of 2·29 to 1 (2·29 being Glaisher's factor[1] for 40°), then a straight line, passing through X and say 38° on the wet-bulb scale, will cut the dew-point scale at 40° − (2° × 2·29), or 35°·4, which is the dew-point corresponding to dry-bulb and wet-bulb readings of 40° and 38°. And by similar triangles any other straight line drawn through X will give the dew-point corresponding to a dry-bulb reading of 40°, and that reading of the wet-bulb represented by the point on CD through which the line passes.

Let a series of points similar to X be taken, using the proper Glaisher's factors, on each of the other horizontal lines, and let them be numbered with degrees like the other two scales. The locus of X will be a peculiar curve, which approaches nearer to CD the lower the temperature. The result gives a dew-point calculator, from which the dew-point corresponding to any given dry-bulb and wet-bulb readings can be instantly found by aligning a straight-edge through the given readings.

To convert the calculator thus formed into a simultaneous calculator for elastic force, all that is necessary is to graduate the other side of the scale AB with the elastic forces corresponding to the various dew-points. Thus the ·250 inch mark will be placed at 40°·3, the ·240 inch mark at 39°·3, and so on. This results in the complete diagram as shown in Fig. 1.

Construction of the Humidity Calculator.

The humidity calculator is constructed from Table VIII. in *Hints to Meteorological Observers*[2] by the following process. Let AB (Fig. 4) be a vertical scale

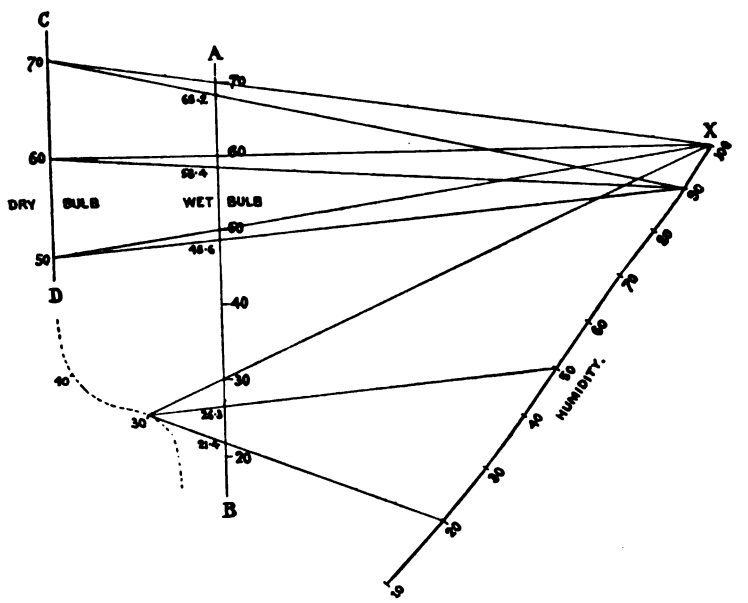

FIG. 4.

of equal parts representing degrees of the wet-bulb thermometer. Let CD be a parallel straight line, and X any convenient point on the other side of AB.

[1] For a list of these factors see Table I., p. iv., in Glaisher's *Hygrometrical Tables*, Ninth Edition, London, 1902.

[2] *Hints to Meteorological Observers*, by W. Marriott, F.R.Met.Soc., Fifth Edition, London, 1902, p. 50.

Taking X to represent 100 per cent of relative humidity, draw radii from it through say 50°, 60°, and 70° on the wet-bulb scale. The intersections of these radii with CD will give the corresponding divisions 50°, 60°, and 70° of the dry-bulb scale, because when the humidity is 100 per cent the readings of the two bulbs are of course equal. (The three selected divisions should not be more than 10° apart, because the dry-bulb scale will not be a straight line for more than a short distance.)

Now from the table we take, for humidity 90 per cent, dry-bulb 50°, wet-bulb 48°·6; dry-bulb 60°, wet-bulb 58°·4; dry-bulb 70°, wet-bulb 68°·2. Lines drawn through these pairs of points will intersect in the 90 per cent division of the humidity scale, which is thus fixed. Proceeding in a similar way, we fix the 80 per cent point, then the 70 per cent point, and so on, always considering only from 50° to 70° of the dry-bulb. (For very different readings of the two bulbs, the three lines may not intersect precisely in a point, but in a very small triangle, the centre of figure of which is taken as the point.) We thus get the complete humidity scale.

It remains to complete the dry-bulb scale by reversing the above process. For instance, to find the 30° mark of the dry-bulb scale, we know that it must lie on the straight line which passes through 100 per cent on the humidity scale and 30° on the wet-bulb scale; we also see from the tables that it must lie on the lines passing respectively through 50 per cent and 20 per cent on the humidity scale and through 26°·3 and 21°·4 on the wet-bulb scale. The intersection of these lines therefore fixes the 30° division. By a similar process we find the remaining divisions of the dry-bulb scale; these will be found to lie on a curve which bends rather sharply near the freezing-point. The degree of accuracy of the scale depends on the closeness with which the divisions are found geometrically; near the freezing-point, on account of the rapid change of curvature of the scale, the individual degrees should be fixed by the process just described; but at higher temperatures than 40° every fifth degree is close enough, the single degrees being found by subdivision after drawing a curve through the main points

It is well to take three or four humidities for each point localised on the dry-bulb scale; for although two are generally sufficient, yet a single pair may not give a very accurate result, owing to the fact that the table gives the humidities only to the nearest whole number per cent.

The convenience of the diagram depends largely on the relative positions selected for the scales; the positions shown in Fig. 2 will be a guide as to what has been found suitable in practice. The aim in calculators of this type is always to get the scales of a fairly uniform degree of openness, while avoiding excessive obliquity of the aligning straight-edge with respect to the scales.

DISCUSSION.

Mr. W. Marriott remarked that this was the second paper which Dr. Ball had communicated to the Society on subjects relating to the reduction of observations. Dr. Ball's method was by no means new. Mr. H. C. Russell, about 1877, published a diagram for finding the relative humidity at a glance from the dry-bulb and wet-bulb readings. Dr. Spong devised an instrument called the "Dew-Point Calculator" (which he showed at the Society's Exhibition in 1894), in which, by placing the adjustable rule in a line with the top of the mercury in the dry-bulb and wet-bulb thermometers, the dew-point and elastic force of aqueous vapour were immediately read off.

Dr. W. N. Shaw remarked that, besides the instruments and apparatus referred to by Mr. Marriott, they had a slide-rule for the same purpose, designed

by Sir R. Strachey, of which a specimen could be seen at the Meteorological Office. Mr. Galton had gone further and had invented a machine for reducing the dry-bulb and wet-bulb photographic records. The important point was that all these contrivances were disregarded in the actual practice of this country. But it should be noted that both Dr. Ball's and Mr. Sutton's papers came from countries with very dry climates, where differences in humidity were of vital importance: one from the sandy plains of Egypt, and the other from the uplands of South Africa. He thought it was a pity that we did not pay more attention to the matter in this country, and that we went on using the tables prepared by Mr. Glaisher, knowing that they differed considerably from those employed in other countries, and yet making no attempt to resolve the differences. The matter was not unimportant: it was simply neglected. Considering the opportunities we had at hand in the British Empire and associated countries for combined investigation, he regretted that no attempt was made to remedy matters. From Egypt we could get observations in a dry and hot climate at practically sea-level; in the Transvaal we have dry and high tablelands with low atmospheric pressure; in Canada there are temperatures as low as need be; while in this country there is the steady succession of almost constant relative humidity at fixed hours. Perhaps it is because we are here so used to a uniform 70, 80, or 90 per cent at our normal observing hours that we do not take as much interest in the matter as we should do. Dr. Mill rightly suggested that we did not feel the necessity for dealing with the question; but we did occasionally have extraordinary conditions, and we ought to be prepared to deal with them when they arose. Our relative humidity values below freezing-point were open to considerable doubt. He knew that we did not often get such readings, but we ought to be able to treat them. Moreover, humidity was subject to very large diurnal variation of great climatic importance, which was practically overlooked by observers whose readings were confined to morning and evening hours. If these papers led to further study in the matter, we should be grateful to the authors for bringing the subject before our notice.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 15, 1905.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

Capt. GEORGE ALFRED ALCOCK, 14 Shrewsbury Road, Forest Gate, Essex;
Lt.-Col. JOHN EDWARD CAPPER, C.B., Highcliffe, South Farnborough;
GEORGE ALFRED DENNY, Johannesburg, Transvaal;
ALFRED THOMAS GOTT, Ph.D., 189 Alexandra Terrace, Bradford;
ROBERT G. F. GRAIN, Iquique, Chili;
EDWIN HOLDING, Balmain, Sydney, New South Wales;
ALFRED ROBERT HUTSON, 123 Darnley Road, Gravesend;
GERALD JOSEPH MACAURA, 4 Spring Bank, Bradford;
Dr. E. M. MODI, Sleater Road, Bombay, India;
ALFRED ERNEST MOORE, B.A., B.Sc., Corrientes, Argentina;
Capt. ALEXANDER SIMPSON, 36 Langham Road, West Green, N.;
JOHN FREDERICK UNSTEAD, B.A., F.R.G.S., 5 Wiverton Road, Sydenham, S.E.;
WILLIAM WARREN, Johannesburg, Transvaal; and

WILLIAM GEORGE WILLOUGHBY, M.D., 17 Hartfield Square, Eastbourne, were balloted for and elected Fellows of the Society.

The following communications were read :—

1. "THE RAINSTORM OF AUGUST 24-26, 1905, IN EASTERN IRELAND." By Sir JOHN W. MOORE, M.D. (p. 1).
2. "THE AQUAMETER." By WILLIAM B. NEWTON, PH.D. (p. 11).

December 20, 1905.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

WILLIAM STEPHENS CLARK, Millfield, Street, Somerset;
Rev. DAVID KENNEDY, D.D., Meeanee, New Zealand;
JAMES LYLE, M.A., Grey College, Bloemfontein, Orange River Colony;
WILLIAM JAMES MARRIOTT, 118 Casewick Road, West Norwood, S.E.;
Mrs. E. V. PEREIRA, Hyderabad, Deccan, India;
JOHN MONTAGUE PHILLPOTT, 48 Tyndall Road, Leyton, E.;
MORTYN DE CARLE SOWERBY SALTER, 3 Oak Villas, Mill Hill, N.W.;
AUSTIN CLARE SAXBY, 397 High Street, Cheltenham;
HERBERT THOMAS SCOBLE, 28 Victoria Street, Westminster, S.W.;
RAMNATH SHASTRI, Hyderabad, Deccan, India; and
Rev. HENRY VAUGHAN, Wraxall, near Bristol,
were balloted for and elected Fellows of the Society.

Mr. E. S. BRUCE and Mr. T. P. NEWMAN were appointed Auditors of the Society's Accounts.

The following communications were read :—

1. "KITE OBSERVATIONS FROM A TRAWLER IN THE NORTH SEA." By GEORGE C. SIMPSON, B.Sc., F.R.Met.Soc. (p. 15).
2. "INVESTIGATION OF THE UPPER AIR AT BARBADOS BY MEANS OF KITES." By C. J. P. CAVE, M.A., and W. H. DINES, F.R.S. (p. 29).
3. "TEMPERATURE OBSERVATIONS DURING THE PARTIAL SOLAR ECLIPSE, AUGUST 30, 1905." By W. H. DINES, F.R.S. (p. 33).
4. "COMPARISON BETWEEN GLAISHER'S FACTORS AND FERREL'S PSYCHROMETRIC FORMULA." By J. R. SUTTON, M.A., F.R.Met.Soc. (p. 35).
5. "A RAPID METHOD OF FINDING THE ELASTIC FORCE OF AQUEOUS VAPOUR, ETC., FROM DRY-BULB AND WET-BULB THERMOMETER READINGS." By JOHN BALL, Ph.D., Assoc.M.Inst.C.E. (p. 47).

CORRESPONDENCE AND NOTES.

Variations in the Circulation of the North Atlantic and the Phenomena connected therewith. By Dr. WILHELM MEINARDUS. [Translated from the *Meteorologische Zeitschrift*, September 1905, by Dr. R. H. Scott, F.R.S.]

The great ocean currents are admitted to be caused by the force of the prevailing winds, which, after they have produced a certain condition of movement, have only to overcome the viscosity which offers resistance to water motion. We may assume that the system of ocean currents is so fully in

agreement with the existing condition of atmospheric circulation, or rather, better to say, is so far asymptotically approached to the condition of perfect agreement, that no material alteration in one direction can take place ; but that besides, the climatic condition of the atmosphere and the distribution of land and water, specially the course of the coasts and the conditions of depth of the sea, may remain mainly the same as now.

On the other hand, there are non-periodic oscillations, of greater or less duration, which occur in the atmosphere and ocean about the mean condition of equilibrium, and show how close is the relation between the phenomena of the air and sea. Changes in the direction of the wind are reproduced in the water movements, and thereby influence the distribution of temperature, of salinity, and of the organisms of the sea.

Now it is of course obvious that the non-periodic deviations of the wind conditions from the normal can only exert a deep-seated and lasting influence on the slowly moving water masses, if they are of long duration. As temperature changes of short duration are speedily used up in the upper strata by the action of passing currents of opposite directions, such as occur when a depression passes over quickly, this consideration must give us a hint as to the line to be followed in investigating the relation between the atmosphere and organic phenomena. The study of daily weather charts, with their changing pictures of pressure and wind, gives less prospect of success than the distribution of pressure over long periods (decades, months, and seasons). We must eliminate the ephemeral variations by combining the individual variations into mean values, so as to arrive at the more stable elements of the weather. These last are the only ones which have a permanent effect on the ocean phenomena.

I. In order to examine *the non-periodic oscillation of the North Atlantic air circulation*, there are two methods of inquiry available. We can either study their course by the monthly isobaric charts, which have been supplied for the last seventeen years by the Deutsche Seewarte and the Danish Meteorological Institute; or we can make out pressure differences between suitably selected points, and put down their variations as a measure of the greater or less intensity of the Atlantic circulation.

This second method has the advantage of allowing us to study the phenomena over a much longer period, provided that we choose such points as present a long period of observations. In what follows, the latter method has been adopted.

In the choice of pairs of stations whose differences of pressure are to be calculated, it was obvious that the line of connection between the stations should be as far as possible perpendicular to the course of the mean yearly isobars, in order to bring out the non-periodic variations, in which the differences of pressure will come out more clearly. Of course such points were preferable as presented a long series of observations. This condition gave us the subjoined three pairs of stations :—

1. Toronto (East Canada) . . .	Ivigtut (S.W. Greenland).
2. Ponta Delgada (Azores) . . .	Stykkisholm (Iceland).
3. Copenhagen	Stykkisholm.

The lines of connection of these points are, as a glance at the yearly isobars shows, nearly perpendicular to the normal isobars. They connect the Icelandic depression with the surrounding areas of high pressure. The common period of observation begins for the first pair with 1875 ; for the second, with 1866 ; and for the third, with 1846. For each month the differences of pressure for the pairs of stations and yearly means are taken, but on the principle that the civil year (January to December) was not taken, but the twelve months beginning

with September and ending with August. It has been shown by other inquiries, which need not here be mentioned, that in the Atlantic system of circulation the more continued positive or negative deviations from the mean in meteorology and oceanography very often set in in autumn. *The atmospheric condition over the North Atlantic and the adjacent continents begins a new year in autumn.* For this reason the calculation of means for the interval from September to August was justified.

The three upper lines on Fig. 1 show the variation of the monthly means of the differences between the stations indicated.[1] The variations in individual years are very considerable, as the subjoined table shows:—

Annual Means of Pressure Differences (in millimetres).

	Normal.	Greatest Variation. Positive.	Negative.	Amplitude.
Toronto-Ivigtut (1875-1900)	7·7	+2·5 (1890)	−2·6 (1888)	5·1
Ponta Delgada-Stykkisholm (1866-1900)	10·8	+5·4 (1868)	−6·1 (1881)	11·5
Copenhagen-Stykkisholm (1846-1900)	5·7	+4·7 (1863)	−6·5 (1888)	11·2

It appears that in the year 1888 (really September 1887 to August 1888) the pressure differences between Central Europe and Iceland were negative, so that the pressure in Iceland in the yearly mean is higher than in Central

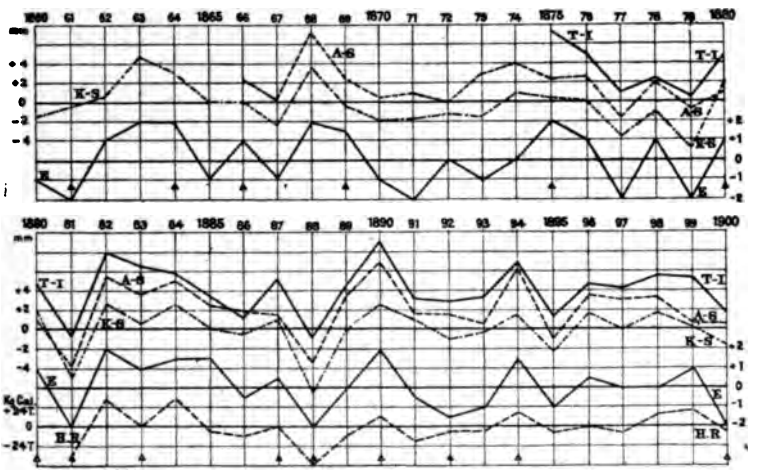

FIG. 1.

T-I = Difference of Pressure between Toronto and Ivigtut.
A-S = Do. do. Azores and Stykkisholm.
K-S = Do. do. Copenhagen and Stykkisholm.
E = Character of the Ice Season at Newfoundland.
H-R = Amount of Heat in the North Sea water at Horns Riff.
△▲ = Ice-poor and Ice-rich years in Iceland.

Europe. On the other hand, the difference of pressure in the yearly means may be almost double the normal value, as *e.g.* in 1863.

The comparison of the three curves on Fig. 1 shows that the variations

[1] As has been explained above, the yearly mean for 1890 is the mean of the months from September 1889 to August 1890. The deviations from the normal are represented as ordinates. The line marked "0 mm." represents the normal difference of pressure between Copenhagen and Stykkisholm. The zero line from Azores to Stykkisholm lies one line above, and that from Toronto to Ivigtut two lines above. The distance of the horizontal line from Toronto to Ivigtut has a value of 1 mm. for the curve T-I, and of 2 mm. for each of the other two lines.

of pressure in the north-west, central, and north-east parts of the North Atlantic usually run in the same sense, and therefore *that the whole area of the Atlantic is similarly affected by either an increase or diminution of the mean pressure directed to the Icelandic centre, and that this affects the atmospheric circulation.* The whole North Atlantic area and the adjacent coast form a unit, as has already come out from Hildebrandsson's inquiries, which showed that the Icelandic depression is in a compensation system with the anticyclone of the Azores and their neighbourhood.[1]

This fact must possess a great importance for the water circulation, that variations of the atmospheric circulation must bring about corresponding variations of oceanic circulation. We may therefore assume that the great currents of the Atlantic (north of lat. 40° N.)—the Gulf Stream, the Labrador current, and the East Greenland current, with all their branches and outliers—show certain characteristic changes which correspond to those of the air circulation. An increase of the latter, or, if we take the most obvious cause for this action, an increase of the difference, should produce an acceleration, a diminution should produce delay of the currents. Alterations of the velocities of warmer or colder currents show themselves in temperature variations, as I have shown in an earlier paper; and I have endeavoured to prove by facts these partially early results to have been supported by the following conclusions, which are based on a more complete series of observations.

II. We must now determine in what way these non-periodic variations of pressure differences, of which we have spoken before, come out *in temperature variations of the Gulf Stream.*

In the region of the Gulf Stream and its branches we possess observations for many years from British, Danish, German, and Norwegian ships. Similar observations have been made on the west coast of the Atlantic, but in a form unsuited to the present inquiry. They will also give no immediate insight into the variations of the Gulf Stream, as the North American coast is well known to be protected from the Gulf Stream by the "cold wall." This inquiry must therefore be confined to the non-periodic changes of water temperature on the coasts of Europe (and Iceland). To characterise these variations, we may take two sets of temperatures from the rich store of materials. One shows the variations on the west coast of Norway, between Udsire and Ona; the other, the Horns Riff, the Danish lightship off the west coast of Jutland.

As we were able to calculate a general mean temperature for each month of the years 1874-1901 for the coast of Norway from the three stations Udsire, Ona, and Hellisö, and for Horns Riff, where daily, besides the temperature of the sea surface, the temperatures at different depths were observed down to 32 m. (105 ft.). The temperature of a water column 1 sq. m. in section and 32 m. (105 ft.) in length was calculated for each month of the years 1880-1902. It is therefore the variations of surface temperature on the Norwegian coast and the temperature of a water column at Horns Riff which are compared with the variations of pressure differences in what follows.

In order to investigate and show the connection between the problems in question, I have employed the process introduced by Prof. Buys-Ballot into meteorology, and which has not as yet met with sufficient attention—the principle of excess.[2] The excess of an element, *e.g.* of temperature, is the algebraic sum of

[1] Lately Hann (*Sitz. Ber. Wiener Akad.* 1904, part 1, and also in the *Met. Zeitschrift*, 1905, p. 64) has more carefully examined the opposite behaviour of the pressure variations of Ponta Delgada and Stykkisholm and compared the two with the simultaneous temperature observations over North-West Europe. These showed similar relations to those I showed for pressure difference, Copenhagen-Stykkisholm. The subjoined explanations complete these references from the hydrographical side.

[2] Köppen gave a fuller account of the meaning of this excess, *Oesterr. Zeitschrift*, xvi. p. 237, and Buys-Ballot in *Met. Zeitschrift*, vi. p. 375.

the deviations, calculated from a definite point of time. If an uninterrupted series of positive observations occurs, the excess increases steadily; it decreases if there is a deficit. We can therefore take the pressure differences with which we are now dealing, or the changes of temperature of the water column at Horns Riff.

In order to explain the calculation of the excess, the following extracts from a large table will suffice. On the first horizontal line we have the normal mean monthly value of the temperature of the water column at Horns Riff, of which we have been speaking, in thousands of kilogram-calories.[1] Then follow the calculated values for the months 1880 to 1882, and under these the variations of these values from the normals. These variations only serve for the calculation of the excess in this way, that they are continuously summed from January 1880 on, with careful noting of the sign of the deviation (last part of table). Thus the figure + 149, which is the excess for December 1882, represents the sum of all the monthly deviations of the years 1880-1882.

HORNS RIFF, WEST COAST OF JUTLAND.

Heat contained in a water column 1 sq. m. section and 32 m. (105 ft.) length in thousands of kilogram-calories.

Mean 1880-1900	I. 125	II. 89	III. 84	IV. 139	V. 242	VI. 339	VII. 439	VIII. 493	IX. 494	X. 414	XI. 306	XII. 208	Year. 281
1880 . .	127	99	118	161	252	364	455	503	533	406	257	207	290
1881 . .	87	37	18	89	188	297	452	492	476	363	248	218	247
1882 . .	182	152	164	211	293	407	503	527	506	433	290	150	319
Variation from Mean.													
1880 . .	+ 2	+10	+34	+22	+10	+25	+16	+10	+39	− 8	−49	− 1	+ 9
1881 . .	−38	−52	−66	−50	−54	−42	+13	− 1	−18	−51	−58	+10	−34
1882 . .	+57	+63	+80	+72	+51	+68	+64	+34	+12	+19	−16	−58	+38
Excess (calculated from January 1, 1880).													
1880 . .	+ 2	+ 12	+46	+68	+ 78	+103	+119	+129	+168	+160	+111	+110	
1881 . .	+ 72	+ 20	−46	−96	−150	−192	−179	−180	−198	−249	−307	−297	
1882 . .	−240	−177	−97	−25	+ 26	+ 94	+158	+192	+204	+223	+207	+149	

It may be pointed out that the normal annual change of heat in the water column is 410,000 kilogram-calories, and the extreme values come in March (84,000) and in September (494,000),[2] but the three years show how very great the non-periodic variations are. In March 1881 the water column had 66,000 kilogram-calories too few, and in the same month 1882 had 80,000 too many. The deviations in March and in the adjacent months in some of the following years were even greater, and the amplitude of the extreme values, 180,000 kilogram-calories, reaches almost the half of the mean annual heat exchange.

In the same way as has been given above, the values of the excess have been calculated for the water temperatures on the coast of Norway and for the pressure differences Copenhagen-Stykkisholm. If you plot down the values as ordinates and the months as abscissæ, you get curves which show most clearly the times at which the tendency to positive or negative deviation prevails. This mode of representation has a decided advantage over the usual one which has been employed, and in which the curves range along a central line, as it shows the occasional quite ephemeral interruptions of a period with

[1] A calculation of the absolute heat of the water is not possible; we must set out from a convection base, and for this 0° C. is taken. The temperature, therefore, will take a negative value if the temperature of the column is under 0°.

[2] See J. Schubert, *The Exchange of Heat in Soil, in Water, and in the Atmosphere*, Berlin, 1904. See also the Report thereon, *Annalen*, July Heft, p. 339. Schubert has taken small calories, and as surface is 1 sq. cm., his figures are therefore one-tenth of those above.

positive or negative tendencies which come out as casual deviations without disturbing the course of the curve. So, *e.g.*, the isolated positive deviation of Horns Riff in July 1881, in the middle of a negative period, in the curve of excess on Fig. 1 appears only as a small hump on a descending curve.

In this method, therefore, you have a convenient mode of perceiving at one glance how the + and − deviations come out in a long period ; and the comparison of many such curves allows of the recognition of the agreements or differences between them.

The curves of excess given on Fig. 1 are an extract from a longer paper, and apply to the ten years 1880-1889. One thing must be noted, and that is the agreement of the temperature and heat curve with the curve of pressure differences. This shows *that positive or negative deviation of pressure over the North Atlantic*, or, in other words, *an increase or diminution of the Atlantic current, falls in with increased (or lessened) temperature of the sea on the European coast. Often the changes in temperature come in from one to three months after the corresponding variations of the changes in atmospheric circulation*, as a close examination of the curves shows ; for the turning-points of the excess curves of pressure differences are often reached some months before those of temperature and heat. In the year 1885 the advent of the turning-point was delayed half a year.

The relatively uniform course of the curves is also a proof *that the tendency to + and − deviations of pressure differences and of temperature is usually of long duration.*

If we neglect small interruptions, the duration of similar early signs of temperature on the west coast of Europe is, on an average, less than a year. The tendency to a change in the early signs is, as has been shown, greatest in autumn.

These facts prove most clearly the close connection between the atmospheric circulation over the North Atlantic and the approach of the Gulf Stream to the coasts of Europe. Changes in the intensity of circulation evince themselves, as a rule, first after some months in a change of the temperature on the coast, as must be the case if the heat comes from a long distance. The long duration of similar early signs shows that there are agencies which tend to maintain the strengthening or weakening of the atmospheric circulation once set on foot. I have formerly made the attempt, on a much less copious material, to give an explanation for this great tendency to keep up conditions, and I think I can now confirm that.[1]

III. We now turn to the north-west part of the North Atlantic, in order to see what action the variations of atmospheric circulation produce. We have first to consider the Labrador current. Long-continued measurements of temperature and force of current do not exist. We must content ourselves with other indications, which can give us a measure of the intensity of the current, and for the Labrador current it is only the ice on the coast of Newfoundland that we have to deal with.

From a summary which was made at the instance of the Hydrographic Office in London,[2] and from notes in the *Annalen der Hydrographie und maritimen Meteorologie*, and also in the *Monthly Weather Review* and in the *Pilot Charts*, I have put together a short account of the amount of ice about Newfoundland

[1] *Met. Zeitschrift*, 1898, p. 102.

[2] G. Robinson, *A Report on the Movements of the Ice Currents and Tidal Streams on the Coast of Newfoundland and in the Gulf of St. Lawrence*, London, 1889. A monograph upon the ice of the Labrador current will shortly be published by L. Mecking. A part of it has already appeared under the title *Die Eisdrift aus dem Bereich der Baffin-Bay, beherrscht von Strom und Wetter*, Berlin, 1905.

for the individual years 1860-1902. The character of the individual years was noted on a scale of five divisions. A very abundant ice year was marked + 2, a very weak one − 2, and a normal one 0. For the years since 1880 it was good and feasible to express the ice richness down to half a degree of the scale. Thus I obtained a series reaching from 1860 to 1892, the values of which have been used in drawing the fourth curve on Fig. 1.[1]

The subjoined table gives a concise view of these conditions :—

Character of the Ice Conditions, Newfoundland.

Years	0	1	2	3	4	5	6	7	8	9
1860 .	−1	−2	+1	+2	+2	−1	+1	−1	+2	+1·5
1870 .	−1	−2	0	−1	0	+2	+1	−2	+1	−2
1880 .	+1	−2	+2	+1	+1·5	+1·5	−0·5	+0·5	−2	0
1890 .	+2	−0·5	−1·5	−1	+1·5	−1	+0·5	0	0	+1
1900 .	−2	−1	−2							

If you prepare a curve representing the varying ice richness in Newfoundland with the three curves above it, which may be considered to represent the general circulation over the Atlantic, *a general agreement in their course comes out. There is therefore a close connection between the force of the North Atlantic ice circulation and the ice in the Labrador current, in the sense that an increase in the circulation accords to an increase, a weakness to reduction, of the ice in Newfoundland.*

If we arrange the years as to the amount of ice, and for each degree of the scale put in the pressure differences between the three pairs of stations, we get the subjoined figures :—

Character of Ice Years in Newfoundland, and Corresponding Deviations of Annual Means (September to August) of the Pressure Differences over the North Atlantic.

Intensity.	Toronto-Ivigtut.	No. of Cases.	Ponta Delgada-Stykkisholm.	No. of Cases.	Copenhagen-Stykkisholm.	No. of Cases.
	mm.		mm.		mm	
+2	+2·1	3	+3·5	4	+2·9	6
+1	+0·5	8	+0·9	10	+0·6	11
0	0·0	7	+0·3	10	+0·2	10
−1	−0·8	3	−1·2	5	−1·4	7
−2	−1·9	5	−3·5	6	−3·4	7

A further investigation showed that in individual years the autumn and winter months were decisive for the magnitude of the year's mean of the pressure differences. From this fact we have *the possibility, from the amount of pressure differences in autumn and winter, to make a guess in advance* of the amount of ice coming to Newfoundland, which reaches its maximum in spring. After a thorough testing of the conditions in the last two or three decades of years, we find—

1. *The Pressure Differences, Toronto-Ivigtut, for the interval September to January;* or
2. *The Pressure Differences, Copenhagen-Stykkisholm, for the period August to January or February,*

give the basis for the best forecast. A strong positive deviation of these pressure differences gives a forecast for the coming spring of a serious ice-drift; a strong negative one, of a weak drift. You can then, at the beginning of February, calculate the variation from the normal of the pressure differences for the season, and from that draw up a forecast for the coming ice season.

[1] In the paper by Schott, in the *Annalen der Hyd. und mar. Met.* 1904, p. 307, on the character of the ice conditions of Newfoundland, 1880-1891, the ice limit is given to show the position of the ice border, while I have given in the first instance the quantity of ice. In individual years a different estimation of the ice season comes out, especially in 1882, which is given in the *Monthly Weather Review* as one of the severest ones, while Schott treated it as a normal one.

In the period 1875-1900, before the seven most icy years, a mean deviation of the pressure differences, Toronto-Ivigtut, of + 2·2 mm. (+ ·087 in.) was noted, and for the six iceless years a deviation of − 2·6 mm. (− ·102 in.). For the pressure differences, Copenhagen-Stykkisholm, there were in the period 1860-1900 the corresponding deviation of + 2·7 mm. (+ ·106 in.), mean of ten ice-rich years, and − 3·9 mm. (− ·154 in.), mean of eight ice-free years.

L. Mecking has come to a similar result as regards the ice forecast for Newfoundland, as he summarises his results in the following way :[1]—

"The amount of berg ice to be expected in Newfoundland (by that we mean the glacier ice coming from Greenland, in contradistinction to sea ice) is determined by the character of the preceding summer, so that a year which is rich in icebergs is marked by specially high pressure in East Greenland, and by a much-developed minimum over Baffin's Bay, in contrast to the much less developed Icelandic portion of the North Atlantic depression area, so that to the eastward of Greenland an extensive high-pressure excess is present, which tends to compensate for the low pressure over Baffin's Bay at one point, and consequently keeps itself to the isobars running across Greenland, and, with a flat bend over Baffin's Bay, comes as an East wind on the fiord coast of Norway about lat. 70° N. An ice-free year will be determined by a summer condition, in which the conditions of the ice-rich years vanish more or less, so that it is only a weakening of the characteristics, whereby, however, a slight tendency towards the formation of an independent type is exhibited. In summer weather this is most decisive ; autumn and winter only modify the conditions."

The law for sea ice is less complicated, and runs thus :—

"The sea ice which appears in any year on the Newfoundland coast is determined by the pressure gradient in the preceding months November to January between South Greenland and the mouth of the St. Lawrence. In fact, the ice quantity is simply directly proportional to the magnitude of the gradient."

The law for the sea ice closely resembles that I have given above as the best grounds for the Newfoundland ice forecast: the pressure differences between Toronto and Ivigtut for the period September to January. Mecking's law has an independent value. The whole character of the ice season in Newfoundland seems to me to be mainly determined by the pressure relations in the autumn and winter. G. Schott [2] has pointed out the possibility of ice-forecasting on the same principles as I have laid down. This mode of ice-forecasting supposes that we have early information as to the pressure conditions of the autumn and winter in Iceland and South-west Greenland, which is another reason for insisting on the realisation of the old plan of telegraphic communication between the Danish colonies and home. Until this is effected, we must content ourselves with the pressure observations and wind conditions over the British Isles and the east of Canada in order to arrive at an idea of the development of the North Atlantic circulation, for which, with advantage, the international decade reports can be employed, and these, as is well known, give the pressure conditions over the central portion of the ocean.

We may observe that in the curves of excess on Fig. 1, as to the connection between pressure differences and ice conditions, a rise of the curve towards the end of the year indicates an icy year (see 1882, 1884, 1885, 1887, 1890). A sharp descent points to an ice-free year (1881, 1888).

By the reasoning given above, we confirm the suggestion I made some years ago, without being able to confirm it by fuller material, that an increase in circulation on the two sides of the Atlantic has an opposite influence on the heat-carrying powers of the ocean currents.[3] While it accelerates the Gulf Stream, it raises

[1] See the note on p. 58.

[2] *Annalen der Hydrographie und mar. Met.* 1904, p. 309.

[3] *Zeitschrift der Gesellschaft für Erdkunde*, Berlin, 1898, p. 195.

the temperature on the west coast of Europe; but as it accelerates the Labrador current, it increases its power of carrying ice and probably reduces its temperature, which certainly has not yet been determined owing to want of material. If the circulation is reduced, the opposite effect takes place. In both cases a delay of several months occurs in the development of the action of the increased or diminished water circulation on the temperature, and I consider that that gives one the possibility of forming a prognosis for both sides of the Atlantic. W. Brennecke has recently shown that a similar delay exists between the action of the pressure distribution over the Atlantic and the ice richness of the East Greenland current.[1]

In consequence of the opposite thermal action which the increase (or diminution) of the North Atlantic circulation has on the opposite side of the Atlantic, it is clear that the total heat in the Atlantic is but slightly affected—the greater heat on one side will be more or less reduced by the greater cold on the other. The Atlantic circulation, with its non-periodic variations, has not the power of an independent heat regulator which helps the increase and diminution of heat between certain limits. We might even conceive the opposite case, that an increased circulation, besides an increase in the ice-flow of the Labrador current, might produce a reduction of the temperature of the Gulf Stream. In this case the variations of the circulation would come out in very sensible changes of the temperature of the North Atlantic Ocean.

As we saw, greater (or smaller) pressure differences, September-January, between Copenhagen and Stykkisholm cause ice abundance (or defect) in Newfoundland in spring. Now I have shown before that these very pressure differences give an estimate for the spring temperature in Central Europe.[2]

In most cases, ice-rich years in Newfoundland are accompanied by warm springs in Europe, and ice-free years by cold. This fact contradicts the constant assertion of the public in the papers, as to a direct connection between the ice in Newfoundland and the European weather. As this representation only rests on an indeterminate feeling, or on a false generalisation of passing weather conditions, it requires no further contradiction.[3]

Meanwhile, we must consider the evident probability that the temperature of the Gulf Stream is later on influenced by the thawing process in Newfoundland, and that in ice-rich years, which show a strengthening of the cold Labrador current, it gets a negative deviation, and in ice-free years a positive deviation is given to it at this point and is carried along with it.

As the water of the Gulf Stream, under normal conditions, takes one-half to three-quarters of a year to reach the coasts of Great Britain and Norway from Newfoundland, we might expect *a priori*, after a great ice season, of which the maximum is reached in April or May, to meet the first signs of a negative deviation on the coasts of Europe. This conclusion is justified in many cases, but in some not so decisively as after the ice years 1882 and 1884. On the other hand, the very ice-free years in Newfoundland, as 1892, were followed by very low temperatures in European waters (1893). It seems therefore that the suggested relation has not the character of a rule which would allow us to frame reasonably safe temperature prognosis for Western Europe.

This fact may seem somewhat extraordinary, but at least the subjoined explanation may give an interpretation. The cold and less saline waters of the Labrador current dip under the higher temperature of the Gulf Stream, although they contain more salt, and probably continue their course to the southward. A considerable mixture of this heterogeneous water may perhaps take place in the lower boundary of the Gulf Stream, but hardly in its upper strata. Water

[1] *Annalen der Hydrographie und mar. Met.* 1904, p. 49.
[2] *Zeitschrift der Gesellschaft für Erdkunde*, 1898, p. 198; *Met. Zeitschrift*, 1898, p. 94.
[3] See Schott's remark in *Annalen der Hydrographie und mar. Met.* 1903, p. 206.

temperature variations of the Labrador current would therefore tend to go to the lower rather than to the upper layers of the North Atlantic. It is otherwise with the changeable amount of ice carried along. The bergs and floes do not sink with the water which brings them from the north, but as they meet the Gulf Stream they lose their original base below and are carried directly into the warm current. They thaw in the Gulf Stream water, and this process must contribute to the withdrawal from the Gulf Stream water of a variable amount of heat, according to the amount of ice present. In ice-free years the cooling is small, and so a positive temperature deviation must result. In ice-rich years the opposite must occur.

Now it is exactly south and south-east of Newfoundland that the main point of divergence of the warm current coming from the south appears. At this point the Gulf Stream spreads out like a fan. The spread of the fan is more than 90 degrees. The left-hand branch turns into Davis Strait, the right-hand branches down southward towards the Azores. This division of the current must also act on the thaw water of the ice masses, which, however, make only a small portion of the water brought by the Gulf Stream. The cooling effect must therefore gradually disappear with distance from the starting-point; but the cooling action generally affects only one or other of these branch currents, while the other is not touched. This will show that the amount of ice near Newfoundland is not regularly affected by the branch of the Gulf Stream which is directed to the north-west European coasts.

IV. The third current of the North Atlantic, which is of importance to the circulation and the temperature of the sea, is the East Greenland current with its branches, especially that flowing between Jan Mayen and Iceland to the south-east, the so-called East Iceland current, which is of influence on the ice conditions about Iceland.

W. Brennecke has recently, in his paper, brought proof that for the character of the ice conditions in the East Greenland seas the pressure differences between lat. 70° N., long. 20° W., and lat. 70° N., long. 20° E., in spring are decisive. By great pressure differences, the North-east winds are accelerated over the ice current, which then brings its ice southward quicker and in greater quantity. The results of Brennecke's investigations, which are based on consideration of the ice conditions in the East Greenland seas in the years 1881-1895, are as follows, in his own words:—

"1. The position of the ice boundary in summer between Spitzbergen, Greenland, and Iceland, depends on the pressure gradients between Greenland and North Scandinavia in the months of March-May.

"2. As a cause of the abnormally great pressure differences from Greenland to North Scandinavia which brings about a development of ice, we may consider on the one hand the deepening of the minimum in North Scandinavia, and on the other the increase of the Greenland anticyclone.

"3. Of the influence of the position of the ice limit in the East Greenland sea we have also the amount of the gradient between Greenland and North Scandinavia; but this is in the second line.

"4. In the very ice-rich years, the depression of the surface temperature of the East Greenland sea and of the air temperature in Iceland and the north of Europe (March-May), while in the ice-free years the temperature is always above the normal."

The connection here mentioned between the distribution of pressure and ice conditions, which seem to resemble those for the Labrador current, induced me to use a longer period of observation, and observations made at a land station to compare the pressure differences between Stykkisholm, Iceland, and Vardö or Christiansund (in Norway) with the ice conditions in Iceland, which

latter can be actually characterised for about 100 years. It appears, therefore, that here in general (that is, in 70 or 80 per cent of the cases) the conditions mentioned take place, so that relatively high pressure in Iceland gives abundance of ice; lower pressures, little ice.

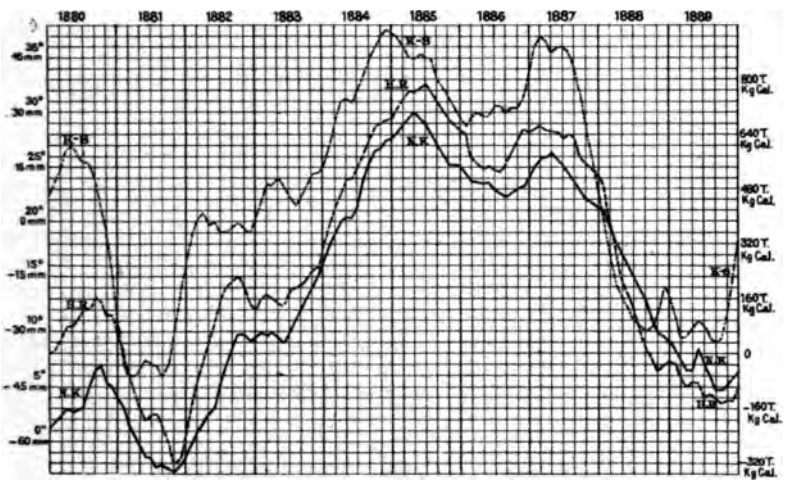

FIG. 2.

K-S = Excess of Pressure differences, Copenhagen-Stykkisholm.
H-R = Do. Amount of Heat at Horns Riff (in thousandths of Kg. Cal.).
N-K = Do. Water Temperature on the Norwegian Coast.

But now, as we have seen, the relative heights of pressures in Iceland are materially important for the greater or less development of the North Atlantic circulation, with its consequences as regards the winter temperature in West Europe and the spring temperature in Central Europe, as well for the ice conditions in Newfoundland; as higher pressure in Iceland on one side gives an increase of ice in Iceland, and on the other a lesser pressure produces a reduction of ice in Iceland, and an increase of atmospheric circulation with its results. The following phenomena are closely and intimately connected :—

A. 1. Weak Atlantic circulation (August-February).
2. Low water temperatures on European coasts (November-April).
3. Low air temperatures in Central Europe (February-April).
4. Little ice in Newfoundland in spring.
5. Much ice in Iceland in spring.
6. Bad wheat and rye harvest in Western Europe and North Germany.

B. 1. Strong Atlantic circulation (August-February).
2. High water temperature on coast of Europe (November-April).
3. High air temperature in Central Europe (February-April).
4. Much ice in Newfoundland in spring.
5. Little ice in Iceland in spring.
6. Good wheat and rye harvest in Western Europe and North Germany.

The similar run of the curves of the upper diagrams on Fig. 1 bring these conditions to the most concise form for discussion. The extreme cases of ice-rich and ice-poor years in Iceland are shown by special signs.

The phenomena named under A6 and B6 I have, so far as harvest

reports from Germany allow, already connected with the winter temperature of West Norway and Central Germany.[1]

These inquiries have brought me to the conclusion that the wheat and rye harvests of Western Europe, especially France, in their variations almost unexceptionally correspond with the variations of temperature in the preceding winter (November-January) at Christiansund. We may therefore draw conclusions as to the yield of the winter wheat crop from the temperature of the preceding winter in Western Europe.

There are naturally exceptions to this rule, as we cannot expect otherwise; for the connection of so many factors cannot be expressed by a short formula. There are exceptions in one or other directions. Ice abundance in Iceland does not always fall in with ice poverty in Newfoundland, and *vice versa*. Thus the year 1882 was rich in Newfoundland (perhaps also 1866 and 1869).[2] It was poor in ice in both districts, *e.g.*, in 1900 (and perhaps 1861), but generally the rule holds true. The years 1864, 1875, 1880, 1884, 1890, 1894, and 1903, which were poor in ice for Iceland, are counted among the heaviest ice years in Newfoundland; while the years 1881, 1888, 1892, 1902, which were icy in Iceland, are represented as uncommonly free from ice in Newfoundland. Also Schott has independently come to the same conclusion as to the alternation by comparison of the ice conditions in Newfoundland and East Greenland in the years 1880-1891.[3]

If exceptions to this development of the ice season occur on the two sides of the ocean, they seem to be due to an abnormal condition of Iceland, not to the Newfoundland water. The ice conditions in Newfoundland correspond to the conditions pointed out above as to their relations to the Atlantic circulation, which is not so often the case in Iceland. This cannot surprise us when we realise that, after Brennecke, the formation of the pressure minimum in the North Arctic Ocean is of great importance for the ice in the East Greenland current. Therefore the development of the air circulation in the extreme north-east of the Atlantic is decisive, and it will be the question to prove in what degree this factor comes to rival the other relation when it produces an exception to the rule given above. In the year 1882 there was an exception: the ice-richness of Newfoundland corresponded to the great increase of the North Atlantic circulation, but there was a strong ice block in Newfoundland, against above rule. It was the result of an unusual development of the pressure minimum at the North Cape. Other apparent exceptions to the rule may be produced by the branches of the East Greenland current going through the Denmark Strait and loading it with ice at the expense of the East Iceland current, so that the Polar coasts of Iceland are relatively ice-poor, and the observations then give no conclusions as to the true character of such a year.

Besides these factors, others come into consideration, which we have only come to know in the last few years by Garde's organised reports on ice conditions in Copenhagen. The question plays an important part, Whether, in the source of the Polar current, a large store of ice is prepared and only waits carriage to the south, or if, by a strong development of the Polar current, the ice-hoard is small because the supply is small and restricted? L. Mecking has shown, as above, that the pressure distribution over the northern side of the Atlantic in the previous season is of great importance.

This consideration brings us to far beyond the narrow limits of the investigation, but that is more impossible when we try to follow phenomena from year

[1] *Verhandlung des VII. Int. Geog. Congress*, 1899, Berlin, 1901.

[2] For the earlier years the determination is rather uncertain. The best collection is a sort of ice chronicle of Iceland by the famous investigator of Iceland, Thoroddsen, published in 1884 in the Swedish journal *Ymer*, pp. 145-160.

[3] *Annalen der Hydrographie*, 1904, p. 305.

to year in order to discover the conditions which call for an increase or reduction of Atlantic circulation. For this we must have, above all, a deeper view of the oceanography and meteorological conditions of the tropics, and that we do not possess.

Scheme for diffusing a Knowledge of Meteorology.

In August 1905 the following letter was sent to the Secretaries of the various local Scientific Societies, Public Schools, Educational Committees, etc., and also to the Fellows of this Society :—

70 Victoria Street, Westminster,
London, S.W., *August* 1905.

Dear Sir,—The Council of the Royal Meteorological Society are desirous of advancing the general knowledge of Meteorology, and of promoting an intelligent public interest in the science. They think that these ends can be most readily attained by means of Lectures delivered in connection with Scientific Societies and Institutions in various parts of the country.

The Council have now appointed a Lecturer who is prepared to deliver Lectures on Meteorological subjects, *e.g.*: How to observe the Weather; Weather Forecasting; Climate; Rainfall; Thunderstorms; Meteorology in relation to Agriculture, Health, etc. The Lectures will be illustrated by lantern slides from a large collection in the possession of the Society.

Societies and Institutions wishing such Lectures will be expected to pay a moderate fee and to defray travelling expenses.

The Council are willing to arrange for exhibiting, at the gatherings of local scientific societies, institutions, or schools, a collection of Photographs, Drawings, Diagrams, and Charts illustrating Meteorological Phenomena, and of various patterns of Instruments used for Meteorological Observations. They would also, if desired, lend and fit up a complete Climatological Station for exhibition, showing the necessary instruments in position and ready for use.

The cost of transit and the expenses of a member of the staff in fitting up and superintending the Exhibit would be borne by the Society or Institution inviting the co-operation of the Royal Meteorological Society.

The Council are further prepared to lend sets of Lantern Slides, illustrating Meteorological Phenomena and Instruments, at a charge of 1s. per dozen and cost of carriage (minimum amount 3s.).

Should you desire further details on the subject, a communication addressed to the Assistant Secretary, Royal Meteorological Society, 70 Victoria Street, S.W., will receive immediate attention.—We are, Dear Sir, Yours faithfully,

Francis Campbell Bayard,
Hugh Robert Mill, } *Secretaries.*

The Council appointed the Assistant Secretary, Mr. William Marriott, the Lecturer, and he has given Lectures on meteorological subjects at the following places during the months of October, November, and December :—

October 9–November 6.—Mayfield House, Old Southgate (a course of Five Lectures).
October 24.—Epsom College, Epsom.
November 8.—Northfleet and District Scientific Society, Northfleet.
„ 10.—Wellington College.
„ 18.—Wimbledon Literary and Scientific Society.
„ 21.—Manchester Geographical Society.
„ 23.—Marlborough College, Wilts.
„ 24.—Holmesdale Natural History Club, Redhill.
„ 25.—Ealing Scientific and Microscopical Society.
„ 27.—Oundle School.

November 28.—Redcar and Coatham Literary Institute.
„ 30.—Blundell's School, Tiverton.
December 11.—Maldon Christian Association.
„ 19.—Croydon Natural History Society.

Meteorological Exhibits, including a typical Climatological Station, have been shown (under the charge of Mr. W. J. Marriott) at conversazioni in connection with the following Societies :—

October 11.—Walsall Literary Institute.
„ 25.—Rochester Naturalists' Club.
November 3-4.—Rochdale Literary and Scientific Society.

Pallant's MS. Meteorological Journal, 1790-1842.

Mr. A. W. Preston has recently presented to the Library of the Royal Meteorological Society the long and valuable MS. Meteorological Journals kept by the late Mr. Thomas Pallant from 1790 to 1842.

Mr. Preston purchased these Journals from the late Orlando Whistlecraft, of Thwaite, in 1883. Mr. Whistlecraft, in his letter to Mr. Preston, May 30, 1883, gave a brief account of Mr. Pallant, and, as this letter is interesting in other ways, it is printed herewith :—

"My dear Sir,—I must first acknowledge with thanks 5s. to hand for the loan of the MSS. which I have this day put on John Mills's cart on his return from Ipswich past my door. He takes them now to Eye where he lives, and will leave the lot on Saturday at the George, in the Haymarket, for you, about noon, where you will find the box well corded and pay the carriage. I bargained to *sell* (but not to lend), carriage free, you remember: 12s. if selling, but 5s. on loan and you pay carriage. Look over and into them a fortnight. You will find all from 1790 to 1842 ; his earlier notes from 1786, when he was only twelve years old, I never had entire nor legible.

"We had to mix them out of course to fit them in the box, and then tie on an extra parcel outside, but you will find each year compact from 1816 in the Ciphg. Books. All the previous years are each in two or more oblong, stiff-covered forms—one for Wind and Weather, another for the readings of the Barometer and Thermometer, all dated outside, so can select and arrange them. For your instruction, however, in making out the details daily, I must show you that the statements are at 8 a.m., 2 p.m., and 8 p.m., and real minima and maxima given on the side. And mind this also, he begins his notes (say if for 2 p.m.) opposite to the 2 in column, and if much to state he writes upwards for a line or two instead of the usual way, and has sometimes to *cram*. Hence you will understand them and find them useful, and I am told such things just now may fetch £10 in the book market, but I am quite certain I fool them away at 12s. If you buy you can act in accordance, but if you return them I do not refund carriage, nor pay for their return. Were I young I would not sell, but as it is, it will be better so ; and a really good job for you also, a chance you will never again have.

"The box will square the carriage if not returned.

"Does your friend require a copy of my Lecture, 1861, or one of the Tables for 1834-35 ? I think I can find one of each, please say, and acknowledge the books to hand.—With best regards, Yours truly, O. Whistlecraft.

"A. W. Preston, Esq.

"I thank you I am rather better, but not right, and mainly owing to harass of mind.

"Thomas Pallant, Esq., the writer of the MSS. (was the son of a surgeon at Harleston, Norfolk), born May 1, 1773. Lived a bachelor all his life. Removed to Palgrave, Suffolk, 1800, then to Redgrave, Suffolk, 1805, where he

died very suddenly of apoplexy, October 22, 1842, and wrote down his notes, as you will see, to the evening previous. He was of good means, and very hospitable, courteous, charitable, kind, and humorous.

"Very fond of music, and had an organ, piano, brass and other instruments, and a set of 36 hand-bells down to 'Double C,' and often musical visitors staying at his house.

"He died intestate, and I obtained the MSS. from the Administrator to the 'Personal.' You see he was in his seventieth year. I used to visit him for a day in 1838 to 1841, four or five times yearly, and much enjoyed it, his company individually more especially."

Green Flash at Sunset.

When the sun, or a bright star, sets in very clear weather, the last ray is a vivid green flash. The phenomenon is frequently observed, but very little has been published about it, and I would draw attention to it in hopes that some one may give an explanation of it. I observed it in the South Pacific in July 1880, and on one occasion watched *α Eridani* to the horizon, changing its colour to brilliant red and green alternately as it neared the horizon.

In October 1898, in the North Atlantic, I watched the sun flash green at setting; but Venus, which set shortly afterwards, turned red occasionally, but did not show a green flash. In November 1905, in the North Atlantic, I saw the green flash at sunset, and the officers of the *Kildonan Castle* told me that they had frequently observed it.

The phenomenon is noted in *Knowledge*, April 1889, p. 126; in *Nature*, March 27, 1890, p. 495, and April 10, 1890, p. 538; and in the *Monthly Notices* of Royal Astronomical Society, May 1901, p. 484, but there still seems much to be added by way of explanation.—J. P. MACLEAR, Chiddingfold, January 1906.

[The following Note on "The Green Ray at Sunset" appeared in the U.S. *Monthly Weather Review*, for September, 1905 :—

The observation of the green ray seen just as the last glimpse of the sun disappears below the sea horizon was originally introduced into meteorology by Tyndall as an evidence of the special absorptive power of the aqueous vapour in the lowest layer of the atmosphere. A short memoir on this subject was lately published by W. H. Julius in the *Archives* of the Academy of Sciences of the Netherlands, and in reviewing this work in the *Physikalische Zeitschrift*, 1905, p. 24, Dr. H. Schering says:

"After a short résumé of the phenomena as described by others, according to whom the so-called green ray appears, as a greenish-blue column of light or flame that is seen on very clear days at the moment of the appearance at sunrise or disappearance at sunset of the upper edge of the sun, behind the horizon, Julius describes his own observations near Sicily and Suez, in the Red Sea and the Indian Ocean. According to him, at sunset the yellowish orange segment assumes gradually a greenish tint, while the sun's limb is sharply defined and without any other colour. The green also extends beyond the neighbourhood of the orange segment, especially is it visible at the two ends of the segment at the instant when, by the junction of these ends and the disappearance of the sun, it assumes the form of a small flame. The duration of the phenomenon varies somewhat, but may be estimated at two seconds.

"Sohnke, Schülke, Ekama, and others explained the green ray as a consequence of the dispersion due to refraction. But the execution of a short computation gives for the breadth of such a green-blue border produced by dispersion at the sun's limb, when it is in the horizon ten seconds of arc, and when it is ten degrees above the horizon, 1·6 seconds. That is to say, the phenomenon should not last more than two-thirds of a second of time at sunset behind the

natural horizon in the tropics, and only one-tenth of a second of time when the sun disappears behind a mountain at ten degrees above the horizon. Since this older explanation does not agree with the author's observations, Julius proposes another namely, that the phenomenon is produced by anomalous dispersion, and that in fact the free ions, which, according to Ebert and Lenard, are most numerous in the upper strata of air, are in general the cause of the terrestial absorption. In this way the rarity of the phenomenon, its dependence on meteorological conditions, and its slow diminution of duration with the altitude above the horizon may be accounted for. But H. Schering remarks that independent of the fact that, according to the latest measurements in free balloons made by Luedeling as well as by Gerdien, an increase of ions at the greatest altitudes is not probable, there exists such a great difference in the magnitude of the number of ions and the number of molecules in a cubic centimetre that we ought not to expect such a spectral effect as Julius assumes, even if the ionization were many thousand times greater than is ordinarily found. In fact, the average number of ions in a cubic centimetre is only 1×10^3, whereas the number of molecules is 2×10^{19}."—EDITOR Q.J.R.M.S.]

Aurora Borealis, November 15, 1905.

The auroral display on November 15, 1905, was seen in all parts of the British Isles, as well as in other countries. The following are extracts from reports which have been received from several observers:—

Baltasound, Shetland.—Aurora 6 to 9.30 p.m., coloured. Fine display.—T. E. SAXBY, F.R.Met.Soc.

Aberdeen.—Aurora first noticed at about 5.50 p.m., and at that time consisted of an arch of greenish white light low down on the northern horizon, the centre of the arch varying approximately north-north-west (true bearings). This arch rose gradually, and streamers of a brilliant greenish light began to shoot upwards towards the zenith. The streamers increased in number, and finally became a more or less continuous curtain, swaying gently. When the arch had reached an altitude of about 45° it suddenly became suffused a bright rose colour, and then flushed deep crimson, the curtain of streamers still remaining greenish white. A narrow band of pulsating white light now formed in the east-north-east and increased into an arc lying between east-north-east and west-south-west parallel to, and a little above, the crimson arch. Shortly afterwards this band and the streamers coalesced and formed a very slight corona situated approximately beside π^2 *Pegasi*. The smallness and faintness of the corona was very marked compared with the brilliance of the rest. Soon after the corona had made its appearance the aurora rapidly faded, and by 6.30 p.m. was over altogether. The brilliancy of the colouring and the intensity of the light were both exceptional, and far surpassed anything of the kind seen here within recent years.—G. A. CLARKE.

Keswick.—Aurora, brilliant, 7 to 9 p.m.—A. M. DAWSON, F.R.Met.Soc.

Southport.—Aurora, brilliant, 5.50 to 6.5 p.m., between clouds.—J. BAXENDELL, F.R.Met.Soc.

Llandudno.—Aurora, 6.30 to 9.30 p.m.—W. LITTLE.

Market Drayton.—Aurora with rosy streamers about 6 p.m. for a short time.—P. WRIGHT, F.R.Met.Soc.

Ross.—Aurora, brilliant, deep carmine colour, till 8 p.m.—H. SOUTHALL, F.R.Met.Soc.

Haverfordwest.—Aurora, brilliant, 6 to 9 p.m.—E. P. PHILLIPS, F.R.Met.Soc.

Raunds.—Aurora, fine display, 6 to 8 p.m.—L. G. H. LEE, F.R.Met.Soc.

Bennington.—Aurora, red.—Rev. Dr. J. D. PARKER, F.R.Met.Soc.

Clacton.—Aurora, splendid display. First noticed as a broad beam of a rosy red hue in the north-west about 8.50 p.m., and by 9 o'clock had extended

almost entirely across the sky towards the north-east, with several shafts radiating from it toward the north. By 9.5 it appeared to be at its maximum beauty, then gradually dying off until only one shaft of light remained in the north-north-west. At 9.25 it had entirely disappeared. Only the one tint was observed. The wind at the time was a gentle breeze from the North. Cloud Strato-cumulus. —A. W. SHADICK.

Shaftesbury.—Aurora, very fine, after lightning, 7 to 9 p.m.—Rev. F. EHLVERS.

Epsom.—Aurora, very bright crimson. First became visible in the north at 7.30 p.m., where a narrow arc of a pale yellow hue spanned the horizon, the segment of sky beneath the arc being quite black. Frequent displays of rays and streamers were noticed, rising and falling rapidly from the arc, their colour varying from a pale pink to a blood-red crimson. Towards 8.45 p.m. a considerable brightening of the aurora took place, and it had moved upwards towards the zenith. The sky at the time was covered with alto-cumulus moving from a northerly point, a succession of bright lunar coronas being visible, in which the predominant colour was green. By 8.55 p.m. the aurora had extended considerably and was of an irregular form, a most noticeable feature being the variability in colour, fading at times to a pale subdued pink, brightening up with a peculiar twitching movement to a deep crimson, the interspaces of the blue sky between the alto-cumulus being illuminated a blood-red crimson. The phenomenon lasted to 9.30 p.m., when a clearance of cloud from the sky took place, and by 9.35 p.m. all traces were lost.—SPENCER C. RUSSELL, F.R.Met.Soc.

Tunbridge Wells.—Aurora, good display at times till about 9 p.m.—F. G. SMART, F.R.Met.Soc.

Woolacombe.—Aurora, 6.30 to 9 p.m.—R. N. KIVELL.

Whitchurch, Tavistock.—Aurora, 6.20 to 6.40 p.m., and again with brilliant red colour with yellow streamers from 8.45 to 9.30 p.m.—E. E. GLYDE, F.R.Met.Soc.

Sidmouth.—Aurora, red.—Miss RADFORD.

Teignmouth.—Aurora, fine display visible in north-east about 9 p.m.—W. C. LAKE, M.D.

Falmouth.—Aurora, 8.30 to 9.30 p.m.—E. KITTO, F.R.Met.Soc.

Ardgillan.—Aurora, fine display, with lightning, 9 p.m.—Capt. E. R. TAYLOR, F.R.Met.Soc.

Dublin.—Aurora, brilliant, with lightning, between 8 and 9 p.m.—Sir J. W. MOORE, M.D.

Sallins.—Aurora, brilliant, 7.20 to 9.10, when it suddenly disappeared.—Rev. W. P. HACKET, S.J.

The letters from Aberdeen and Clacton were forwarded by Dr. Shaw, the Director of the Meteorological Office, to Dr. Chree, the Superintendent of the Observatory Department of the National Physical Laboratory, who replied as follows :—

"With reference to the two letters which I received from you this morning, there was a marked magnetic storm on November 15, a very remarkable movement of the declination needle taking place between 8.55 and 9.25 p.m., and thus somewhat about the same time as Mr. Shadick observed the aurora to be most brilliant. The magnetic storm commenced really early in the afternoon and lasted for over 30 hours. There are special features about this storm and one occurring three days earlier, which I have described in a short communication which I am sending this afternoon to *Nature*. Mr. Clarke's description is exceedingly good and well worthy of being published. A Mr. Sangster wrote me from Sutherlandshire relative to the aurora there, but particularly with regard to some magnetic observations he had made, which showed much

disturbance. Mr. Fox also reports large magnetic disturbances at Falmouth. When Mr. Clarke says the aurora was over by 6.30 p.m. this must, I think, represent merely an interlude. Mr. Sangster observed it at Rogart at 7.40 p.m. and 9.30 p.m.; his view was much interfered with by clouds."

The Lifting Power of Ascending Currents of Air.

Mr. H. H. Clayton, of the Blue Hill Observatory, U.S.A., contributed the following note on this subject to the U.S. *Monthly Weather Review* for September, 1905:—Several instances of the lifting power of the ascending currents of air in ordinary quiet summer weather have come to my attention, and may be of interest to students of the atmosphere and aeronautics.

The first was on August 6, 1894, soon after beginning work with kites at Blue Hill, when a small kite belonging to Mr. Eddy was caught in an ascending current about 50 feet above Blue Hill, and lifted rapidly toward the zenith circling above the heads of the observers as it rose. The string hung loosely beneath the kite, which continued to draw up fresh string from the ground as it ascended. A large cumulus cloud was passing the zenith at the time, and after the kite had risen some 500 feet it slowly followed the cloud off toward the east, but continued to ascend until 1172 feet of cord had been carried up and the kite was estimated to be about 1000 feet above the hill. At this point the kite was drawn out of the ascending current, and being unable to support its own weight and that of the string fell rapidly to the ground. This description is condensed from notes made by me at the time. The occurrence was witnessed by some half-dozen persons, among them being Mr. John Ritchie, jr., of Boston, Mass., who sends the following account of a similar occurrence:—

"On Friday September, 8, 1905, the walking party of the Appalachian Mountain Club observed a curious atmospheric phenomenon, the action apparently of a vortex. The party had reached the northern summit of Chocorua in the Sandwich Range, N. H., a subordinate peak, which itself rises sharply from its valleys; its height above the sea is about 3000 feet. The party was seated on the summit engaged in consuming the luncheon, when Mr. J. A. Alden called attention to the movement of a bit of a paper from his box. It was a piece of common paraffine paper, perhaps six by four inches, and had been folded. It was blown out of the box by the wind and, instead of drifting horizontally or settling, it began at once to rise in the air. It retained its folded form, making three sides of a parallelopipedon, there being no ends. The day was perfectly clear and there was very little wind stirring. The sky was bright, blue, and a few small cumulus clouds hung about, not more than half a-dozen and all of them small. One of the clouds was to the north of the peak and the others to the south. The attention of the party was directed to the paper which floated steadily upwards with moderate velocity. It was not as if blown by a gust of wind, but rose quietly and steadily. We watched it until it became difficult to see, even with the sun shining on it, and finally lost it. We estimated that it had risen at least a thousand feet before it became invisible. It rose at a small angle to the vertical and disappeared at an apparent elevation of about 70° above the horizon. It did not drift in the direction of any clouds, but midway between the two groups. Its general drift was to the west."

In my opinion both the kite and the paper were lifted by ordinary ascending currents of air such as commonly exist on summer days. It will be noted that in both cases, the objects started from a considerable elevation above sea level, where the currents had decided vertical velocity. It is probable that near the ground over a level country the air can have no great vertical motion, except in whirlwinds, so that phenomena of this kind are not observed. The kites flown at Blue Hill frequently give evidence of strong vertical uplift when

they are at a considerable distance above the ground. On May 1, 1900, a kite weighing eleven pounds, carrying a meteorograph weighing three pounds, and 1000 feet of wire weighing about five pounds, was lifted to an angle of 90° above the horizon as measured by a theodolite, and remained in the vicinity of the zenith for nearly two minutes.

Relation of the Temperature of the Lowest Air Stratum to that of the Upper Layer of the Ground and of Water. By A. Woeikof. [Translated from the *Meteorologische Zeitschrift*, January 1906, by Dr. R. H. Scott, F.R.S.]

Owing to the lower heat capacity of the air we must expect that the air will in general be affected by the solid and liquid surface below it, and not *vice versâ*. But yet the influence of the air is important, if greater masses of it stream over land and sea; with water this influence is increased also by the formation of waves, which increase materially the surface exposed to the air.

Much greater is the influence when small portions of the solid and liquid remain long in the air, for then the amount of surface in contact with the air is great in proportion to its mass.

Such cases are:—1, falling hail; 2, rain; 3, snow falling from clouds; or 4, drifted; 5, the drift carried along by the wind; and finally, 6, dust and small sand. I now leave these small portions of the mass of solids and liquids and return to the surface of solid and liquid and the air resting thereupon.

The observations on the oceans have shown that on the mean the lower stratum of air is about 0°·5 C. (0°·9 F.) colder than the upper stratum of water. As the daily periodical as well as the non-periodical variations of temperature in the water are small and proceed slowly, so that the air can follow them. Where cool winds prevail, as in the Trade wind and Monsoon region, the cooling of the air in relation to water is greater than the general mean; but where, on the contrary, warm winds are frequent, as in the oceans of the mean Latitudes in autumn and winter, the air is often warmer than the water.

These circumstances are explained by the fact that the exchange between air and water does not take place, because warmer or colder air comes in, and these masses influence the air temperature at the spot very considerably, but that of the water very slightly.

Specially large contrasts between water and air temperature come out under the following conditions:—

1. Where cold and warm currents come close to each other. This occurs chiefly in the neighbourhood of Newfoundland, where the Labrador current and the Gulf Stream come close together. By the interference of cyclones and anti-cyclones there are frequent occurrences of cold winds on the Gulf Stream, and warm on the Labrador coast. In the first case the air is much colder than the sea, in the second much warmer.

2. Where in winter a cold continent lies close to the sea. The winds are mostly from the continent, and bring air, which is colder than the surface of the sea, in high latitudes even than the very cold sea, if only it is not frozen. In our hemisphere the sea in the neighbourhood of Eastern Asia, Eastern North America, and the islands lying north of it. In this condition near Eastern Asia the cooling of the air in relation to the sea must be greater on the mean, owing to the greater prevalence of North-west winds in winter (the winter Monsoon). It is doubtful if such a condition exists in higher southern Latitudes for the air descending from the continental ice warms itself markedly in its descent. The observations on the coast of Victoria Land have shown the Föhn character of the continental South-east winds.

3. Warm winds in summer from dry continents are rarer than cold ones in winter, for in summer the pressure on the sea is greater and sea breezes blow

in the daytime. But the land winds are not absent, and where land and sea breezes alternate, the former are delayed till the late morning hours and then bring very warm air over the sea. As these winds coming from the land sweep off the upper warm water layers, and cooler water from below rises up, the contrast between the warm air and the cold surface of the water is greater. According to observations which we possess the sharpest contrast of the kind is to be found in spring on the coast of Senegambia, where, close to the sea, towards noon (the end of the land wind), air temperatures of 40° C. (104° F.) occur while the surface of the sea is at 20° C. (68° F.). It is possible that there is a sharper contrast on the east coast of Africa, for in summer the water near Ras Hafun is very cool; and the South-west wind coming off the land, brings hot air. On the east coast of the Caspian, the same conditions often prevail, the East wind from the land brings warm air from the desert, and the surface of the water is cool.[1]

In the two cases cited above we have winds which blow pretty steadily at certain times of the year or the day. Perhaps there is a stronger contrast between the relatively cold water surface in South Australia, and the warm winds blowing at times from the continent. I am sorry that I have no full printed observations which show this in figures.

Frequent comparisons have been made between the temperature of the air and that of inland lakes, and in some printed observations there are figures for both. The longest series of this kind are Geneva (at the exit of the Rhone from the lake),[2] and Parc St. Maur, near Paris (Marne[3]). These two very valuable series do not give the air temperature over the water, but at a higher station, and one some 100 metres (330 ft.) distant from it.

Forel compares the temperature of the surface of the Lake of Geneva, in the deep-water region, which he makes out by interpolation, not with the air temperature over the water of the lakes, but with that near the shore.[4] He finds that the water temperature, in the yearly mean, is more than 2° C. (3·6° F.) warmer than the air; in December, over 5° C. (9°·0 F.); but in April and May, somewhat cooler. If we could compare the air temperature over the Lake of Geneva with that of its surface, it is certain that the latter would be on the mean in all months warmer, in spring the same, but in winter not so much warmer than in Forel's Table. For the air is warmed in April and May by the land, in winter it is cooled.

The same holds good for other short series; with few exceptions the water temperatures of lakes and rivers are compared with an air temperature which is much more influenced by the land, which is near it, than by that of the water.

The observations of some travellers make an exception, which they have carried out by comparing the water temperature taken from a boat with that of the air; but such observations are too isolated. Forster[5] has given the greatest series of means of temperature of rivers and comparisons of these with the air temperature, and his work is the more valuable as it deals with an area which is not too great, and does not deal with varying classes of rivers. The surface of glaciers, springs, and lake rivers he found in the summer half year considerably cooler than the air, naturally, as the water is cooled by certain actions which either do not, or very slightly, influence the air.

The fourth category, the rivers of the plain country, have no such causes of cooling and are warmer than the air in summer, except the Danube at

[1] During the expedition to Karabughas, 1897, 12°·5-13°·5 C. (54° 5-56°·3 F.).
[2] For many years in the *Archives des Sciences de Genève.*
[3] Since 1878 in the *Annales du Bureau Central Météorologique de France.*
[4] Forel, *Le Leman*, Lausanne, 1895.
[5] Forster, *Temperatur fliessender Gewässer Mitteleuropas, Geog. Abhandlung.* v.

Peterwardein and the Theiss at Szegedin. These exceptions are easily intelligible; on the plains of Hungary the surface of the soil is strongly heated in summer, and so is the air above it. The deep and rapid streams have the same temperature above and below. The surface cannot be so heated as in lakes.

In the same way, the Nile and Amu-Darja are colder than the air,[1] for they flow through highly heated deserts. The surface of the soil warms the air. This air flows over the river, while the water is cooled by rapid evaporation.

The waters of the Amazon, Congo, and Guayaquil rivers have been found much warmer than the air.[2] Here the air is very damp; evaporation, therefore, does not cool the water much. The water is warmed by the sun, but the air is cool in the adjacent woods, where there is constant shade. On the lower parts of the Congo and Guayaquil the wind from the cool sea close by cools the air.

The Marne is a small, shallow, and rather muddy river, and its surface warms itself greatly by the sun's heat. Ten years' observations, 1878 to 1887, show that on the mean of all the months the surface of the water is warmer than the air at the observatory close by. The excess in the seven warmer months varies between 1°·9 (3°·4 F.) in April, and 2°·9 (5°·2 F.) in September. These two months are the most cloudless in the climate of Paris, and April the driest. In September the humidity of the air is much greater, and the winds are lightest. The greater humidity of the air and the weak winds lessen the evaporation, and are very favourable to a great warming of the water during the prevalent fine weather. The surface of the soil and the plants cool the lowest stratum of air in the cold September nights and the frequent calm weather. In the five colder months, air temperatures below 0° C. (32° F.) sometimes occur. I have left these out of the comparison with the water temperatures, and also those in which the air temperatures were above 0° C. (32° F.), but the Marne was frozen. The mean excess of water temperature over air, with these corrections, was November 1°·0 C. (1°·8 F.), December 0°·5 C. (0°·9 F.), January 0°·1 C. (0°·2 F.), February 0°·5 C. (0°·9 F.), March 1°·0 C. (1°·8 F.), year 1°·8 C. (3°·2 F.). There is a regular decrease to the middle of winter. The cause is certainly that in winter dull weather with warm South-south-west and West winds prevail, which warm the air considerably, but the water less. The cold days of winter in which the air is cooled down, with North-east and East winds and anticyclonic calms, are left out of the calculation as the temperature is below 0° C. (32° F.). In the five colder months the air is warmer than the water only with warm winds and dull weather, but in the very warm winter of December 1880 the air was warmer in the monthly mean.[3] In the warmer months such cases occur usually with fine weather, and are referable to the action of the ground, which is heated more easily than the surface of the water. In the subjoined Table An gives the mean number of days on which the daily mean of the air temperature at Parc St. Maur was 3° C. (5°·4 F.) or more above that of the Marne, Amx the mean of the greatest difference in each month, the greatest excesses of the air above the water temperature (marked with +). Bn is the mean number of days in each month in which the air was 5° C. (9° F.) or more colder than the water; Bmx the mean of the greatest excess of the temperature of the water above that of the air. The months January 1879, 1880, 1881, 1885, 1887, and December 1878 and 1879 are omitted because of the great number of frost days. In the other months the frost days, and those on which the Marne was frozen, are omitted.

[1] The Nile in Upper Egypt from May to August by 4°·1 C. (7°·4 F.), in Nubia by 6°·5 C. (11°·7 F.). The Amu-Darja in the same months by 0°·7 C. (1°·3 F.).

[2] The Amazon, according to Herndan and Gibbon, 1°·8 C. (3°·2 F.) on the yearly mean. The Congo 1°·4 to 5°·4 C. (2°·5 to 9°·7 F.).

[3] In the mean of all days, the frost days being excluded.

TEN YEARS, 1878–1887.

Month.	An. °C.	An. °F.	Amx. °C.	Amx. °F.	Bn. °C.	Bn. °F.	Bmx. °C.	Bmx. °F.
January . .	4·0	7·2	+5·0	+9·0	0·6	1·1	−5·0	−9·0
February . .	2·9	5·2	+4·6	+8·3	1·1	2·0	−4·7	8·5
March . . .	2·7	4·9	+3·9	+7·0	2·0	3·6	−5·6	10·1
April . . .	0·9	1·6	+3·2	+5·8	2·9	5·2	−6·8	12·2
May . . .	0·9	1·6	+3·5	+6·3	4·4	7·9	−6·9	12·4
June . . .	0·2	0·4	+1·6	+2·9	4·3	7·7	−6·5	11·7
July . . .	0·0	0·0	+1·1	+2·0	4·4	7·9	−6·7	12·1
August . . .	0·1	0·2	+1·1	+2·0	3·3	5·9	−6·4	11·5
September . .	0·0	0·0	+1·2	+2·2	5·2	9·4	−7·2	13·0
October . .	0·8	1·4	+2·8	+5·0	5·0	9·0	−6·7	12·1
November . .	2·2	4·0	+4·4	+7·9	1·6	2·9	−5·6	10·1
December . .	2·3	4·1	+5·5	+9·9	0·5	0·9	−5·6	10·1
June-Sept. . .	0·1	0·2	+1·25	+2·2	4·3	7·7	−6·7	12·1
Nov.-Feb. . .	2·8	5·0	+4·9	+8·8	0·9	1·6	−5·1	9·2

The number of the greatest positive differences (air warmer by 3°·0 C. (5°·4 F.) has a very regular course; it is below 1° C. (1°·8 F.) from April to October inclusive, and is entirely absent in July. Also the magnitude of the normal monthly differences of this kind is regularly decreasing from winter to summer and early autumn, and again increasing towards winter.

The number of the greatest negative differences increases less regularly, and the mean of the greatest from winter to summer. The maximum goes on to September. I have shown above that the clear days of September with light winds are favourable to a negative difference. The water warms itself greatly in the sun, while the air over the soil is naturally materially cooled in the long nights. I give also the absolute greatest positive and negative differences in two groups of months—

	A.—Abs. Max.		B.—Abs. Max.	
XI.–II. .	+7°·5 C. (XI.)	+13°·5 F.	−8°·6 C. (XII.)	−15°·5 F.
VI.–IX. .	+3·1 (VI. VIII.)	+ 5·6	−10·6 (VII.)	−19·1

So the air in summer in the maximum is above 3° C. (5°·4 F.) warmer than the water, and may be colder than it (10°·6 C. (19°·1 F.). The conditions on the surface of the soil and the air resting thereon I have lately explained in the *Zeitschrift*.[2]

From this we see that the air 20 cm. above the ground may be by day more than 20° C. (36° F.) colder than the surface; even in the monthly means, the air at 2 or 3 cm. high may be colder than the open soil.[3]

Also in the yearly mean the air is 3° C. (5°·4 F.) or 4° C. (7°·2 F.) colder than the open ground in the tropics and subtropics.[1] Why, it may be asked, is the difference between the surface of the ocean and the air so small, and that between the surface of the soil and the air in low latitudes so great?

Certainly on this account: because (1) in the warming by day when the lowest stratum of air is very warm, the vertical equilibrium is disturbed, and some ascending warm and descending cold convection currents arise, which produce heating of a greater air stratum and reduce that of the lowest which is in contact with the ground. At night when this cooling is more active, the vertical equilibrium is more steady, the colder the lowest layer resting on it.

(2) If on the continents on days with little cloud the winds are stronger in the day time than at night, it is often calm at night and there is strong wind by day. By this the daily heating is conveyed to a great vertical air stratum,

[1] Temperatur der untersten Luftschicht, *Met. Zeitsch.*, 1904.
[2] Probleme der Bodentemperatur, *Met. Zeitsch.*, 1904.
[3] *Ibid.*

the cooling at night remains below. The length of time when the cooling alone prevails (night) is much greater than that of the greatest heating (two or three hours on an average), so the temperature of the lowest stratum at night is very nearly that of the surface of the ground and the plants. How are we to explain the fact that in winter on clear days, namely in high latitudes, the thermometers show a temperature much higher than that of the summer? The best known instance is Sagastyr in the Lena delta.

The explanation is simple. We have to deal not with the lowest stratum but with thermometers in Wild's Screen 3 m. (10 ft.) above the ground. At this level the air in winter is much warmer than the snow surface. So the lowest stratum in the winter of high latitudes, in clear weather and with light wind, and so under conditions most favourable to radiation, somewhat warmer than surface (here snow), in summer it is always above the ground, and even in the yearly mean in the tropics and subtropics much colder than the surface (here soil, rock, or vegetation), or, as I have expressed myself before, than the upper active surface of the ground.[1]

The air, too, may have a temperature much less than the surface of the ground, but this comes from the influence of winds from warmer regions. This oftener occurs in higher than in lower latitudes, in winter than in summer, by night than by day, and in dull weather than in fine (namely by day). Otherwise expressed, such cases are more common when the sun is near the horizon, and are more common by day the lower the sun's altitude and the duller the weather.

When high air temperature prevails with sunshine, the surface of the soil and inland lakes are warmed, and when the sun is high, more than the air; but if the sun is not shining, the air has a source of heating in warm winds which acts but little on soil and water.

I compared the temperature of the soil at Pawlowsk, near St. Petersburg, at 1 cm., depth, and at Tiflis, with that of the air at 1 p.m. for a year. At Pawlowsk (59° ¾ N. lat.) the soil from April to August inclusive was constantly warmer than the air, later and earlier warm winds with dull weather brought at times no excess of air temperature.

In the very warm January 1882 the mean of the air temperature was higher, as in these months little snow lay on the ground near St. Petersburg, so that the artificial removal of snow made no difference.

At Tiflis an excess of soil temperature came only on one day in November and December, and three days in January. On the other days even with dull weather a decided solar radiation came through the clouds and warmed the soil.

RECENT PUBLICATIONS.

Cloud Studies. By ARTHUR W. CLAYDEN, M.A., Principal of the Royal Albert Memorial College, Exeter. London, 1905. 8vo. 13 + 184 pp. and 61 plates.

The author, in the Preface, says: "To the meteorologist, I hope the following pages may prove not only of some interest, but of practical value as a small step towards that greater exactness of language which is essential before we can attempt to explain all the details of cloud structure, or even interchange our ideas and observations with adequate precision. The varieties depicted and described have been selected from many hundreds, as those which seem to me

[1] Probleme der Bodentemperatur, *Met. Zeitsch.*, 1904.

[2] Without vegetation or snow.

[3] In a Wild's Screen.

to show such differences of form as to imply distinct differences in the conditions to which they are due. I have not attempted to deal with the physical causes of condensation, except in a general way, being unwilling to introduce diagrams of isothermals and adiabatics and such purely scientific methods into a work also intended for a wider public. . . . I also hope that some more votaries of the science may be induced to realise that meteorology does not consist solely of the tabulation of long columns of records, but includes subjects for investigation as much more beautiful as they are more difficult."

Mr. Clayden's hopes are likely to be realised, for he has produced a very interesting book, which he has illustrated with most charming pictures of almost every variety of cloud form.

In addition to the descriptions of the cloud forms, Mr. Clayden gives the results of his own measurements on the altitudes of clouds, and also describes the method which he has so successfully employed in photographing clouds.

It is to be regretted that the heights of the clouds have been given in metres without the corresponding values in feet.

Hints to Meteorological Observers. Prepared under the Direction of the Council of the Royal Meteorological Society, by WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary. Sixth Edition, revised and enlarged. With Illustrations. London, 1906. 8vo. 70 pp.

This well-known and useful work has now reached its sixth edition. Considerable additions have been made in order to bring it up to date and also to render it as helpful as possible to meteorological observers.

The contents are arranged as follows :—Stations of the Royal Meteorological Society ; Instruments required to equip a Station ; Barometer ; Thermometers ; Hygrometry ; Rain Gauge ; Evaporation ; Percolation Gauges ; Well Measurements ; Wind Direction ; Wind Force ; Sunshine Recorders ; Ozone ; Clouds ; Weather ; Hours of Observation ; Note-book ; Lamp ; Register ; Self-recording Instruments ; Additional Observations ; Phenological Observations : Books and Publications on Meteorology ; English and Metrical Scales ; and Meteorological Terms.

A set of Tables for the reduction of meteorological observations is also included, and these have been extended to take in a greater range of readings than in the former editions.

The Glossary of Meteorological Terms has been revised and extended, and now comprises 275 terms.

On the cover of the book is stamped a reproduction of the reverse of the Symons' Memorial Medal, which includes a design of the Tower of the Winds at Athens.

Lehrbuch der Meteorologie. Von Dr. JULIUS HANN, Professor an der Universitat in Wien. Zweite Neubearbeitete Auflage. Mit 89 Abbildungen im Text, 9 Tafeln in Autotypie, 14 Karten, und 4 Tabellen. 12 + 643 pp. 8vo. Leipzig, 1906.

Hofrath Hann has given us the second edition of his *Lehrbuch*, which has come out in eight parts. The Introduction, dealing with the sources of heat has been posted up to the latest results furnished by the several inquirers.

Book I. is on "Temperature," and this is dealt with in great detail. Results appear from stations in all parts of the world, and quotations from papers in all languages are freely made. The actual number of pages dealing with temperature is not quite so great as in the first edition.

Book II. is on "Pressure," which is dealt with at less length, but there are several fresh quotations.

Book III. treats of "Vapour," its origin, sources, and condensation into clouds, and the result in the precipitation of rain, snow, and hail.

Book IV. deals with "Wind," and much new matter has been brought in. The results of Dines and other modern experimenters are freely given.

Book V. treats of "Atmospheric Disturbances," and occupies the whole of the rest of the volume. The first chapter treats of weather in general, then the explanations of the causes which produce what we term "weather." The third chapter has to do with isobars which do not belong to closed forms, with an account of local phenomena such as the Bora and Föhn. The fourth chapter takes up tropical cyclones, their development and causes. The fifth chapter is devoted to atmospherical electricity. The sixth chapter handles some of the best mathematico-physical theories.

The Science Year-Book, with Astronomical, Physical, and Chemical Tables, Summaries of Progress in Science, Directory, and Diary for 1906. Second year of issue. Edited by Major B. F. S. BADEN-POWELL. London [1906]. 8vo. 8 + 209 + 391 + 6 pp. and 5 plates.

This is a most valuable and useful book, and should be very helpful to the meteorologist, for the Diary, in addition to the usual information as to the times of sunrise, sunset, planets, high-water etc., has spaces for the entry of meteorological observations. There are also printed the "record" maximum and minimum temperatures since 1841, as well as the mean maximum and minimum temperatures for the day at the Royal Observatory, Greenwich.

The book also contains articles by various authors giving summaries of the more important work accomplished during the past year in the various branches of Science.

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The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

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THE METEOROLOGY OF DAILY LIFE.

BY RICHARD BENTLEY, F.S.A., PRESIDENT.

[An Address delivered to the Royal Meteorological Society, January 17, 1906.]

(Plate I.)

> Till warn'd, or by experience taught we learn
> That, not to know at large of things remote
> From use, obscure and subtle, but to know
> That which before us lies in daily life,
> Is the prime wisdom.
>
> MILTON, *Paradise Lost.*

LADIES AND GENTLEMEN,—I will ask you this evening to extend your indulgence to what must be a somewhat discursive survey. Its object is to bring home to us how closely Meteorology enters into the daily life of every one. Confronted to-night on every side either by expert or by amateur votaries of that science, it will be difficult to indicate much that is new—still the array of so many and varied aspects of our atmospheric surroundings must tend to emphasise the daily claims of Meteorology on the public at large.

It is satisfactory to observe with the dawn of the twentieth century greater attention devoted to this topic,[1] and it is only a few months ago that—for the first time—due recognition was given to the importance of studying the physical conditions under which we live by one of our English Universities.[2] It is still more agreeable for me to add that the steady rise in the number of our Fellows—now higher than it has been at any previous time—bears also witness to the increasing interest taken by the public in the observation of the weather on scientific principles.

[1] It was very different about 1763, when Dr. Rutty, the Quaker M.D. of Dublin, found it necessary to apologise for his too great love of meteorology. See his *Spiritual Diary*, 2 vols., 1776.

[2] By the foundation of a Lectureship in Meteorology in the University of Manchester, held by one of our Fellows, Mr. G. C. Simpson.

The strenuous efforts being made at the present time, both at home and abroad, for the exploration of the upper currents of the atmosphere show also how this growing interest has stimulated the leaders of meteorology on the path of new investigation—investigation that is likely before long to be fruitful of very important results.

Climate.

Charles the Second—who never said a foolish thing—accorded the highest praise to the English climate when he said that it allowed you more hours out of doors than any other.

Brought up under such conditions, the English race has shown itself better adapted for the extremes of life than others, in the wide climatic range of its colonisation, extending from the icy shores of Hudson's Bay to the burning heat of the Equator. The tropics, it is true, have been lately robbed of some of their terrors by the patient research of the doctor,—and the yellow fever and malaria, once directly attributed to climate, have now been traced to transmission by insects,—and even Panama has been improved by the removal of rotting vegetable matter.

We may notice the effects of climate in the complexion of the West Country folk, with its apricot-like tints, or in the liquid eyes of the Irish maidens, or in the way in which the pale complexion of the Northern European is succeeded by the olive of the Southern, or the brown and black of the Indian or negro races.

Lord Verulam averred that men lived to a greater age in colder countries than in hot, and in plains rather than in hilly countries. Great travellers, too, he said, were long-lived, owing to frequent change of air.

Again, we may observe the greater indolence of the Southern Europeans—which incidentally leads perhaps to the greater number of monasteries in the South. The distribution of narcotics (opium, hemp, tobacco, hops, etc.) also is chiefly in the tropics and warmer countries. Cold and dryness unquestionably stimulate energy, just as a moist heat depresses it—on the other hand digestion is easier in warm weather. In the moist climate of Ireland the peasants ride where in England they would use their own legs.

It is a truism to refer to the sanguine view of life taken under a sunny sky, or to the gloomy tinge which comes over the outlook under a murky, leaden one. Yet Milton, however, favours Winter, declaring "that his Vein never happily flowed but from the autumnal equinox to the vernal"; and the American, James Russell Lowell, holds an eloquent brief for it in his charming essay "A Good Word for Winter."

There are few ladies present to-night, so I will not touch upon the variations of dress from the furs of the Arctic to the extremely simple garb of the African, or to the difference of weight between our own summer or winter clothes,[1] or to the sudden necessity for extra wraps at the hour of sundown, as in Sweden; but the changes in our habitations due to climate are more curious. One turns from the ice huts of the Esquimaux to the paper houses of Japan, or from the underground homes of the ancient Britons to the stone palaces of St. Petersburg, with huge

[1] Even the amount of food taken varies somewhat with the nature and warmth of our clothing.

stack-pipes to provide for the sudden melting of the snow in spring. The earlier houses being of wood or slender materials were generally sheltered from the violence of the wind and weather in hollows, and this was the more necessary from the scarcity of window glass.

Neither will I remark upon the effects of heat or cold upon animals or insects, their hibernation or changes of coat or differences of structure —the seal and whale, for example, loaded with oil to withstand cold, and the kangaroo, living in a dry, warm country, with none at all—for my predecessor in the Chair has already given us an interesting address on this subject.

In the world of vegetation one might say much also, contrasting the shape of the pine needles to withstand the snow of northern countries with the prickly scrub of the desert, which is water-bearing, and affords sustenance denied by the arid soil itself.

So trying is the climate of Africa that General Lyttelton has found that the fortifications of Ladysmith, though recently erected, are already crumbling away. Atmospheric difficulties have also hindered what would have been most valuable over large and little populated districts, the development of wireless telegraphy in South Africa.

Two illustrations occurring at the moment are evidences of the close connection between Meteorology and Commerce. In the first a public works contractor gave particulars of a loss of close upon £40,000 arising from the great havoc caused by the August 1898 storms on the coast of Yorkshire and destruction of works in progress. In the other a farmer in north Kent was brought to a standstill through bad seasons and floods. Five years previously he was worth £5000, but his grazing land was twice flooded through high tides overflowing the river banks. He lost hundreds of sheep and lambs, and the land was rendered useless for a considerable period after the floods.

A very doleful account is given of the state of southern Essex by a writer a hundred and fifty years ago—it is right to add that it has not been tested by reference to the Church registers. Even if exaggerated, however, it is an indication of the harm to health in malarious, swampy soils.

> In Essex it is frequent to meet with men that have had from six to fourteen or fifteen wives. The reason is that being bred in the marshes themselves and so seasoned to the place they did pretty well, but they generally chose to leave their own lasses to their neighbours out of the marshes and went into the uplands for a wife. When they took the young women out of the wholesome, fresh air they were clear and healthy, but when they came into the fogs and damps in the marshes they changed complexion, got the ague, and seldom held their own for a year at most, and then (said he) we go to the uplands again and fetch another. I was informed of one farmer over by Canvey Island that he was living with his five-and-twentieth wife, and that his son, who was but thirty-five years old, had already had about fourteen wives.—*A Tour through Great Britain in 1748*, vol. i. p. 11.

Coming to the

STATE OF THE AIR

itself we notice how sound is diminished by the rarefaction of the air at great altitudes. The observations of ozone are now nearly discontinued,

but have given place to far more interesting ones of the ionization of the air. It would be irrelevant to refer now to the mode in which air can be artificially cleaned, as demonstrated in the filtered air supplied to the Houses of Parliament close by, or to some of the hospitals in crowded cities, but every one has noticed the natural purification of the air after wind and rain.

It is probably the search for air which causes each seed, either in light or darkness, to grow *the right way up*—its leaves shoot uppermost and its roots downward.

The determination of altitude by the air pressure is well known, and no more remarkable exemplification of this exists than in the chilling and stupendous ascent of nearly seven miles from this earth made by a past President of this Society, Mr. Glaisher, at Wolverhampton on September 5, 1862, when the barometer fell to seven inches. The apparatus used by Mr. Glaisher is now preserved in the museum of this Society. Ascents have been made to even fourteen miles above the earth by *Ballons Sondes*, when the barograph has registered as low as three inches pressure.

With a low barometer, a statistician [Dexter] points out an accompanying tendency to slackness in the individual, and that there is an increase of unruliness, sickness, or even suicide. Some effect can also be traced in tidal height on dock sills in connection with the barometrical pressure, and the colliery risks attendant on a very low barometer, and the release of gases and fire damp are especially guarded against.

We may now pass to the

Precipitation

from the air, which is very irregularly distributed, and consequently large tracts of country are useless for population, such as in the Sahara or Libyan Deserts, in Central Asia, or in the interior of Australia. Other parts of the world are largely dependant upon rainfall being carried to them by rivers, such as Egypt, Persia, or Thibet. While mentioning these water-carriers, it is perhaps of interest to note that the Thames, gauged at Kingston, bears away with its current no less than 1500 tons of lime and minerals every twenty-four hours—and a large river like the Mississippi carries along with it no less than 400,000,000 tons of solid matter in the course of a single year.

Nor is this transfer of soil confined to the river beds. The erosion of rainfall wears down steadily, if almost imperceptibly, the surfaces of hills and mountains in proportion to their hardness of composition, and thus the deltas of the great rivers are silting up. This wearing action is very curious sometimes, as in the case of the upright pillars at Botzen, in the Tyrol, where the softer clay has been washed out, leaving patches of harder rock remaining. The great solvent—rain—is always at work in the weathering of rocks, the wear of surface soil, slipping of new railway embankments, or settlements of freshly made up ground. The especial action of rain on a large scale may be noticed in such places as the Hartz Mountains, the Pass at Cheddar, or the narrow outlet through which the Zambesi finds its way below the Victoria Falls. It is again observable in the bog slides of Ireland or in land slips, such as the one at Lyme

Regis in the last century. Cleopatra's Needle has suffered much from the same cause, aided by the acidity of the London atmosphere, during the few years it has been in London.

We are confronted at the present moment by several serious problems, such as the general decrease recently in the birth-rate all over the world, the diminution in the yield of wheat, the reduction of our store of coal, and lastly, and most serious of all, the falling-off in our supply of fresh water.

This last is very forcibly brought home to us at this instant by the critical state in which so large a town as Leicester is; but it is equally threatened all over the kingdom, as the level of the underground supply continues to sink,[1] and the consumption of water continues to increase. London is especially remiss in making adequate provision for this.

The population of Great Britain and Ireland at the time of William the Conqueror may be estimated as being under two millions, in the reign of Edward the Third as exceeding three millions, in the spacious days of Queen Elizabeth as being under six millions, in the reign of James the Second as seven millions, in that of George the First under nine millions, in 1801 over sixteen millions, in 1861 twenty-nine millions, and in 1901 forty-two millions, or a rise from two to over forty-two million users of water in less than nine hundred years.

Still greater has been the change in the use of water.[2] The original two millions were misers, the present forty-two millions are spendthrifts! We have to reckon with the great increase, happily, for personal use, baths, etc., the flushing of arterial systems of drainage,[3] the daily watering of immense surfaces of roads in summer, use for hydraulic power, for water wheels, for steam factories, for railway locomotives,[4] for electricity, and even for photography. While the use of water is thus vastly extended both by the increase of population and the variety of modes of consumption introduced in later times, the available supply itself is greatly reduced. Land is mostly over-drained; it may suit very wet years, but there is little holding power left in dry seasons, and water which falls on the ground on Monday is in the river on Tuesday, and in the sea on Wednesday. The health of the population may gain thereby, but no reserves are left as in former days in the fens, morasses, or spongy bog-lands—these are largely reclaimed—or in the very soil itself. In Ireland, and in a very few localities in Scotland, it is true there may be occasional exceptions, but there the supply is less needed on account of the extra rainfall and the fewer industrial or manufacturing requirements.

Besides thus robbing the land of its store by the drainage of the top-soil[5]

[1] Below London indeed the well water is sinking nearly as much as a foot every year.

[2] It would be irrelevant to refer here to the connection between drinking supplies and diseases, *e.g.* such as the epidemic which followed the first use of the soft Loch Katrine water when passed through lead pipes, or the frequency of goitre, or the prevalence of stone in certain districts.

[3] By which the land loses in many cases the use of a most valuable fertilising agent. The loss of London alone is an immense one to the agriculturist.

[4] A fast train may use from 27 to 47 gallons of water for every mile run, and a single engine will consume on the journey (in one direction) between Paddington and Plymouth between 30 and 40 tons of water, according to load and weather. A Midland express engine will carry between 3000 and 4000 gallons in its tender, not yet having water troughs on the road to supply it.

[5] The collected water from which should by rights be returned to the strata below by means of shafts.

just referred to, we have also nowadays the sealing up of large areas by houses, pavements, and impervious roads, as in London, Birmingham, Liverpool, Manchester, Leeds, etc., while the rainfall itself is actually less than formerly owing to disafforestation.

The map of England for the next generation will be parcelled out into collecting grounds allotted to the cities—London, which is so sadly behind hand, perhaps omitted [1]—and instead of counties the student will be taught the water areas of Birmingham, Liverpool, Manchester, Newcastle-on-Tyne, Plymouth, etc.

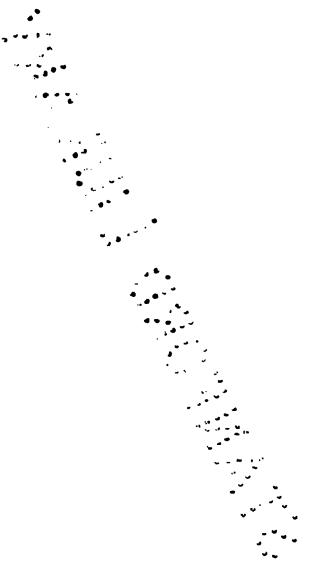
The military vulnerability of large cities nowadays lies in the possibility of cutting off the water-supply, and in recent operations in South Africa this added to the anxieties both of Kimberley and of Ladysmith.

Our champion rainfall at Cherrapunji is unfortunately out of reach, and at home we actually waste the splendid water pumped daily into the Bristol Channel from the Severn Tunnel works. Even our last sponge abroad is to be some day squeezed, namely, the reserve for the Nile, by the projected cutting through of the "sudd."

In civilised countries the engineer can form a very fair judgment of the rainfall of a rural district by glancing at the form and size of such bridges as are already existing. A good gardener can also tell recent wet or dry seasons by noticing the character of the growth of the leaders and shoots of the trees. Much, too, depends on the period of rainfall in the case of fruit trees whether the bark is soft or hard at the season of first budding. The relation of rainfall to the rising and falling of the sap is more difficult to trace, though its influence is apparent; but the incidence of a normal rainfall and its help to farmers in the working of the land at a correct time is known to all. Besides permitting the labour of human beings, the rain allows the worms and moles to work in the soil, and also helps to convert the dead leaves in autumn into mould. The difference between a "summer inch" of rain and a "winter inch" is very great, and one almost needs a measuring glass to vary in capacity with the seasons when making a fair comparison of value between them. While a sufficiency of rain will mark the difference between good and bad straw years, or in the yield of a good root crop, an over-supply in late summer will spell a bad harvest, and crops will even rot. Hence a connection between the rainfall statistics arrived at in Camden Square and the prices quoted in Mark Lane (at one time very marked before the increase in the importation of grain from abroad), and in very bad years the money market itself shows indications, and the railway receipts fall off. As we are in the midst of politics just now, I may too be permitted to recall the historic incident which befell one of Queen Victoria's Governments, of being turned out of office at an election following a very wet summer, because of the general dissatisfaction felt at the weather and at the disastrous results of the harvest.

In overwet seasons money is lost also at Matches (though of late years the gate receipts have frequently been insured beforehand at Lloyds against a rainy day), at many places of amusement—by the

[1] One quarter of the population of England and Wales is resident within a radius of twenty miles of Charing Cross. Despite its increase no beginning has yet been made of the line of supply from the Welsh mountains, to make adequate provision for the future needs of London and its suburbs.



WATERSPOUT OVER THE THAMES AT MAIDENHEAD BRIDGE IN 1853.

railway companies carrying fewer holiday makers, and by shops being less frequented. Building is hindered as well as agriculture, and the outdoor painters lose their wages. The sheep rot, rabbits and hares and even rats perish from fluke and dysentery, and the young grouse suffer.

Excessive rain washes away paint on buildings, wood-work decays, and the acid of the rain conduces to the rusting of iron-work. Doors or gates swell or stick where exposed to weather; weeds flourish. Furniture, books, pictures, and cigars suffer from undue damp, and house linen has to be aired. Food is liable to mildew. Human beings suffer from rheumatism, and cancer is more prevalent in damp situations. On the other hand, fair Americans of excitable temperament are often sent to our more humid climate for nerve rest. Tibullus[1] says that rain disposes to sleep, but Solomon's experience[2] was otherwise.

The watery vapour which surrounds us is necessary for our existence. One must remember, taking a man as weighing (say) 154 lbs., that 110 lbs. of this is water and only 44 lbs. dry material. He evaporates through his lungs and skin nearly 4 lbs. of water a day, and were it not for the moistness of the air, he would soon parch like a mummy or shrivel up like a dead frog. A patient German, Lindenau, made a calculation that the lungs of an adult man had a surface in contact with the air equal by its wonderful structure to 2640 square feet!

Though nitric acid is one of the chief chemical constituents of rain, it may be noted that every gallon of rain-water which falls in England contains on an average nearly half a grain of the salts of the sea.[3]

The movement of insects before storms or rainfall is observable, their antennæ being perhaps, suggests Lehmann, extremely susceptible to any electrical or atmospheric change. Bees possess this faculty in a high degree, and if they desist from work and return home while it still appears fine it may be certain that rain is imminent. If they do not return to their hives until late over night, the following day may be relied upon as a fine one.

In the year 1750 Jonas Hanway invented the umbrella, and for nearly thirty succeeding years was derided for using one before so convenient a protection was received into general favour.

A wet season is a good one for the umbrella-makers and mackintosh manufacturers; the post office and stationer gain by the increased number of letters written, the libraries by more readers, and the cabmen by more fares. The outdoor workmen who are stopped by rain frequent the public-houses, and so the brewer benefits.

In India the character of the monsoon affects very largely not only the yield of the crops, but also the nature of the goods traffic on the railways.

Waterspouts, except at sea, are not very frequent, but one may be mentioned which occurred in the Thames valley near Maidenhead in June 1853, an illustration of which appeared in the *Illustrated London News* at that time and is reproduced in Plate I. (Another and rarer spectacle on the Thames was the mirage seen by Dr. Wollaston, the physiologist, and Secretary of the Royal Society, in London, in 1797.)

[1] *Eleg.* I. 1. [2] Proverbs xxvii. 15. [3] Johnston and Church, *Chemistry*, p. 16.

In times of too great rainfall or sudden melting of snows, we suffer damage in various ways from

FLOODS,

carrying away buildings, walls, bridges, or roads, and sometimes even people and cattle, as well as depositing alluvial and other down-drift where not wanted, and choking back the natural drains and outlets. In 1555, by reason of excessive rains, Southwark, Palace Yard, and Westminster Hall were flooded.[1] On one occasion a flood in the Thames valley robbed a large town (Slough) of its water-supply by submerging the pumping engines at the Water Works, and the floods in 1809 stopped many of the stage-coaches and post-chaises—in those days the principal means of communication.

The serious effects of floods in war time are exemplified by the three Roman Legions lost by Varus in Lippe Detmold, B.C. 9; the defeat of General Bonaparte at Caldiero in 1796, where the ground was so water-logged by torrents of rain that the French Artillery could not be brought up to the front, and again by the loss of Marshal Macdonald's army on the banks of the Neisse and of the Bober during the operations in Silesia in 1813. The battle of Waterloo was postponed from June 17 on account of the heavy rainfall.

Mons. Forestier, Inspector of Roads and Bridges in France, stated in 1900 that "all responsible for roads have agreed that during the rainy season the resistance to the wheel may be taken as treble what it is in fine weather." Our horses unfortunately have the same burdens to contend with (instead of one-third of their ordinary load), and suffer accordingly.

The destruction wrought by tropical floods are touched upon in our archives, and only a few weeks ago an account was given of ravage done in this kingdom at Little Bray. The destruction of the famous canal at Crinan on the western coast of Scotland is historic.

At eight o'clock in the evening of February 2, 1859, after an almost unprecedentedly wet season, one of the reservoirs, created to feed the canal, being overcharged, suddenly burst and precipitated its contents into one below, and the contents of these two bounded over into a third reservoir, and with a roar which is described as shaking the countryside for miles, an avalanche of water, rocks, and earth was swept down the mountain side, obliterating the canal. The huge torrent tore on its course with savage fury, part finding an outlet into Loch Fyne, and the other rushing over the Crinan morasses into the Western Sea.

In March 1864, at midnight on the 11th, the large Bradfield reservoir near Sheffield (the construction of which was not very substantial) burst, and entire villages were suddenly swept away—huge manufactories, mills, and warehouses were engulphed in the roaring current, and only desolate ruins were left to mark what once were prosperous farms and homesteads. Nearly three hundred lives were lost on this occasion.

More recently we have had the traffic on such important railways

[1] Stow's and Strype's *London and Westminster*, I. 32. In September 1841 a similar flood took place, and the floor of Westminster Hall was under water. See too p. 107.

as the London and North Western, the Great Western, and the Metropolitan paralysed by floods. The London and North Western for six weeks by the washing away of a viaduct on their route to Ireland, near Abergele; the Great Western by the flooding of their northern main-line near Oxford (and their western, at one time near Taunton); and the Metropolitan by the bursting of sewers and the escape of flood water into the tunnels. Similarly, the Indian railways suffer on occasion great loss of revenues; and to give a single illustration, last November the Madras railway lost £13,000 from the stoppage of traffic by floods.

A property difficulty often arises in India where some of the large rivers, like the Indus or Ganges, at times of flood carve out a fresh channel for themselves. In such cases a large addition is made to the land of one owner by an older channel becoming dry. On the other hand the river has appropriated for its new bed a large amount of another proprietor's ground, hence not infrequently giving rise to legal disputes.

While the heavy rains of autumn often are the cause of great mischief, by flushing unclean ditches and farmyards, and conveying polluted matter into rivers furnishing drinking supplies, or washing sour, dead, or putrefying leaves into the same, the after-results of floods are also very serious. When the water has receded from the sodden land malarial fevers and agues arise from the miasma. Some of the worst flood years were 1823, 1852, and 1882, and for a few days in May 1886.

Another form of precipitation causes great inconvenience—

SNOWFALL,

especially in the cities and large towns, where the cost of carting it away is very heavy. Still worse is it when salt is wickedly used on roads and pavements to melt it. Very noticeable is the snow when the roar of traffic in some busy thoroughfare is muffled by it. The danger of a heavy weight of snow on large glass roofs of stations and public buildings has to be watched, and Sunday (with so many who are usually on the spot absent) is always a more difficult day.

In social life a heavy snowfall is an element to be taken account of. I note that, near Manchester, in the storm of January 1854, where seventy persons were expected at one evening party only one turned up, and at another house where a hundred guests were expected only nine came.

In the country snow has its redeeming features: first, in its great beauty; secondly, in the way it soaks slowly into the land, and (previously to this) it acts sometimes protectively as a mantle over vegetation during keen frost or cutting, freezing winds. Goethe, according to Lowell, was the first to notice the cheerfulness of snow in sunshine, but its power of lighting up a winter's night is remarkable.[1]

The damage done to trees and shrubs by snow is very great, chiefly by the accumulation of weight breaking them down or straining branches beyond their power of return, and so altering the shapes of trees or shrubs,

[1] In the daytime also, by its reflected light any defect or discoloration of ceilings is made ruthlessly apparent.

and sometimes by pinning down lower portions of plants to the ground, contracting by frost, and tearing them off.

In 1282 five arches of old London Bridge were borne down and carried away through a great frost and deep snow.

FIG. 1.—Holyhead and Chester Mails snowed up near Dunstable, December 26, 1836.

After the great snow-storm of February 1799 the Post Office did not succeed for nearly three months in recovering all their "patent" coaches which had been injured or snowed up.

In January 1814 the fall was so great that, to give a single instance referred to in Macready's *Reminiscences*, there was no conveyance possible by carriage for more than six weeks between Newcastle-on-Tyne and Edinburgh.

Perhaps the most severe downfall, however, was that in 1836, when London was entirely cut off for two days from the rest of England, and no less than fourteen of the mail coaches were abandoned in the heavy drifts. Even in the southern counties the block was as great. The Brighton, Dover, and Hastings mails were stuck fast. The first mentioned, indeed, could not be found for a considerable time, having become completely snowed over. The Bath and Bristol mails were entombed in snow on the Wiltshire Downs, and the Manchester coach was upset in it near St. Albans. The mail from Exeter was five times buried in the snow, and had each time to be dug out. Another coach buried near Louth took (says Mr. Hyde in his interesting Records of the Royal Mail) three hundred men to dig a way to the coach and rescue mails and passengers.

In present times one has witnessed the stoppage of road trams by the blocking of rails and points by snow. The railways, too, have been great sufferers by snow.[1] In January 1854, with a thermometer below zero, both North-Western and Great Northern Railways were completely cut off, the one at Tring and the other at Grantham. The Thames, too, being blocked, coals rose to an immense price, and the metropolis was threatened with total darkness from the inability of the gas companies to procure supplies. In those days there were much fewer routes open.

In January 1876 occurred the terrible triple railway collision at Abbots Ripton, near Huntingdon, on the Great Northern Railway. A signal arm which was supposed to have been moved to "danger" was really standing at "line clear," the semaphore being choked by snow. Since this time it will be observed that the signal arms on this line are hinged at some distance from the post. The extension of the Midland Railway to Carlisle over the Yorkshire moors, owing to the height above sea-level, is liable to the effect of very heavy snowfalls, especially in the neighbourhood of Hawes Junction. In March of the same year occurred

FIG. 2.—Train snowed up near Hawes Junction.

the great snow-storm in Scotland, and no less than twelve trains were snowed up on the way to Aberdeen; and even the admirable system of powerful snow-ploughs running at frequent intervals on the Highland line was powerless in presence of so heavy and continuous a fall. In the same storm the telegraph wires, overloaded with snow, snapped, and communication was interrupted near London. In December (1876) in Ohio, a hundred lives were lost in a train accident through a snow-storm at Ashtabula Creek.

[1] The mild winter in the eastern States of America has been a boon to railway shareholders. One company alone spent in December 1904 £20,000 in removing snow. To last December its expenditure on this account was only £138.—*The Evening Standard*, January 22, 1906.

In a severe snowfall in Scotland in 1879 the most important train on the Highland Railway was *lost*! The wires were broken down under the weight of snow. At Inverness the whereabouts of the 3.10 P.M. Sunday mail was an absolute mystery to the officials on Monday night. The train was known to have passed Altnabreac, and was *believed* probably to be snowed up in the bleak stretch of line near Scotscalder.

FIG. 3.—Railway Snow-Plough with three Engines.

The snow-storm of January 1881 cost one railway alone, the Great Western Railway, no less than £56,000 in restoring communications. As many as 64 trains were snowed up on that system alone. The chairman announced that 111 miles of railway had to be excavated for a depth of from three to ten feet of snow. In January 1881 communication by wire between London and the country was almost entirely stopped. In December 1886, the last occasion of a serious interruption, the snow accumulated and froze to the wires until they became enlarged to immense bars before they snapped.

In one of these snow-blockades just referred to London was in danger of a milk famine, the milk churns being twenty-four hours behindhand getting up from country, and the returned empties being nearly equally late. Smithfield, too, was depleted, the daily meat-trains from Scotland being also in arrear.

The snow-storm of March 1891 was also a severe one. It is more difficult to observe the blinding action of snow at sea, unless in the Polar regions, but we have a sad experience of it lately in the loss of the L.S.W.R. steamship *Hilda* off St. Malo, as well as in that of the *Violet*, an Ostend steamer, off Dover in January 1857.

The winter in eastern Canada a year ago (February 1905) was a very severe one. The side walks of the towns presented a strange appearance, having been cleared to get to the house doors, leaving the roadway in the middle eight and ten feet higher, so that the foot passengers on the opposite sides of the street could not see each other. Staircases had to be cut in the snow at crossings, though sometimes tunnels were dug, through which people walked from street to street. A curious illustra-

tion was given in the country, where a farmer came along in a sleigh on his usual road to what would have been a level crossing on a railway. On reaching the spot he discovered that the line had been cut clear of snow for traffic. Instead of, however, being on a level with it he was confronted by a gulley fifteen feet deep. Fortunately for him the railway men were working close by, and they ran an engine and waggon to the spot, using this as a centre pier, and speedily laid a bridge of planks across the chasm for the farmer to cross over by.[1]

In April 1849 five thousand lambs were lost by a snow-storm in Romney Marsh, and nine thousand were reported to be lost in North Wales in the March 1886 snow-storm.

The Easter snow-storm of 1876, in the middle of April, was a very heavy one both in England and France. Of snow in the south of England later in the year, is the well-known record of the Derby being run in falling snow, when Hermit carried off the stakes in May 1867; and I have come across mention of snow falling at Windsor on June 19, 1795,[2] and even as far south as the Isle of Wight on July 11, 1888.[3]

With the arrival of—

Cold Weather,

we find the collieries in full swing, both owing to the short days and increased call for artificial light, and to the large numbers of domestic fires and use of warming apparatus. This in turn leads to an increase in the number of conflagrations. The cold of waning summer gives us the lovely gold, russet brown, or scarlet leaves of autumn; the appearance of the aurora in midwinter generally presages a hard frost; and severe cold in spring endangers our fruit-supply, wreaks havoc in the lambing season, and taxes the strength of invalids already run down by the darkness and severity of winter, and persons of feeble circulation suffer from the discomfort of chilblains. A very cold spring has a disastrous effect, too, on our sea-fisheries, owing to the loss of spawn chilled when floating in the cold surface water.

Many of the great Chestnut forests in the north of France were destroyed in the severe winter of 1709. Two of the mildest winters were those of 1748 and 1857.

Until the time of Napoleon it was customary for armies, even when engaged in warfare, to go into winter quarters, and desist from active operations in the field. In modern days war is less humane; we have the fearful accounts of the retreat of the French from Moscow in 1812, the sufferings of our own troops around Sebastopol in 1855, and the cruel winter of 1871, when the French and German troops were in mortal conflict around the forts of Paris.

In winter the Trans-Atlantic steamships' lines have to follow a different route on account of the danger of icebergs. In this country, on land, we are not quit of precaution until the "cold days of May," in the latter part of that month, are past, nor is it prudent to put out

[1] The *Railway Magazine*, December 1905, p. 480.

[2] In the pages of *The Annual Register*. See also *Notes and Queries*, Third Series, vol. iii. p. 519.

[3] *The Meteorological Record*, 1888.

bedding plants before June 1; while, if later on in the summer we have temperatures below 42° F., vegetation suffers and even wheat.

One result of a severe winter is observable in the *National Budget*, under the Probate and Estate duties. To cold weather, also, the death of a distinguished Prime Minister is due. On January 19, 1827, the Duke of York was buried by night in St. George's Chapel at Windsor. The members of the Cabinet who attended proceeded to the chapel, where they were kept waiting for two hours, standing on the cold flagstones in very bitter weather. Canning made Lord Eldon stand on his cocked hat, but he took no such precaution himself, and so he contracted the dangerous chill from which he never recovered.

The action of—

FROST

on the surface of the ground is very great, especially after a wet season. The friction marks may still be seen on boulders which have slided down glacier ice, rocks may be noticed split by the action of frost, and quagmires or rivers, ordinarily impassable, may be easily crossed during it, as during the Franco-Russian War in the marshes of Poland.

The Baltic and many of the northern navigations are closed, and in some winters (as in 1855 and in 1895) Derwentwater, Windermere, and Loch Lomond are frozen over. We shall remember Wordsworth's picture of the skating scene in the "Prelude." Abroad railway lines have been laid over ice near Quebec and across Lake Baikal.

Of many historic frosts time only permits reference to that of 1407-8, when nearly all the small birds in this country perished; and of 1683-4, when many hardy forest trees were split, even oaks, and most hollies perished. The freezing over of the Thames, and the fairs held on the river, are of frequent occurrence. The Christmas of 1860 was memorably severe.

A landowner, describing the frost of 1838-9, wrote: "The ground was like a rock; every turnip, swede, etc. rotted. The very wheat even perished, save where it was protected by the drifted snow in furrows. I ploughed up fifty acres of my wheat that year."

Besides the loss of birds, many perishing from thirst, trees suffer severely, especially when the ground is hidden by snow. Hares, rabbits, and even rats and smaller vermin, hard pressed for food, prey upon the green bark, especially of the younger trees.

Frost cleans the ground of insects, and also disturbs the surface. For a time it imprisons the air, etc. and the ground vapours released after a long frost are unwholesome.

We have the stoppage of most ground work during frost and a suspension of building operations, though in Sweden and America this is obviated by the use of unslaked lime in lieu of ordinary mortar. Canals are blocked by ice, and horses have to be "roughed" before using the roads, and extra horses often added to the vehicles. The ice sweepers and the skate-makers get their brief harvest. Among the daily occurrences during or after frost are broken rails or axles on railways—a lamentable instance of which occurred at Shipton on Christmas Eve, 1874, when over a hundred persons were injured; burst water-pipes (it is said that ones oval in section withstand frost better than round ones); boiler explosions;

accidents on the ice—one of the worst of which occurred in Regent's Park in January, 1867, in which a large number of lives were lost; and overheating of flues, which has led to the destruction of many ancient mansions, and sometimes of churches, as at Croydon.

In quarries, occasionally, rock is purposely split by a hole being drilled and water admitted to freeze. On a very dangerous stretch of railway, owing to rock-falls during frost, an ingenious system of protection is used. A number of wires, arranged like a fence, run along the side of the line between Callendar and Oban, but the ends of which are attached to a signal post. The signal arm normally is at "line clear." If a large rock falls on the line it breaks through the wire, and so sets the signal at "danger."

Another result of frost was—what will be familiar history to many under this roof[1]—the failure of the atmospheric railways in work at Croydon, Dalkey, and in South Devon, the leather valve of the longitudinal vacuum tube becoming stiff in frosty weather and tearing away. Even locomotives have to perform their duties under difficult conditions in severe weather, and I have seen one in full steam with icicles pendent along the entire side. One pathetic story of frost comes to mind—that of a driver of a mail-cart over the Downs near Newbury, who, some years ago, was frozen to death stiff and upright on his night journey. The horse knew the accustomed halts, and the man was known as being a taciturn one. At several little village post offices bags were tossed into the cart without reply from the driver; at a subsequent one, when he did not turn round to hand out some in exchange and was asked for them, he was discovered to be a dead man!

In the picturesque little churchyard at Mawgan Porth, in Cornwall, is a tombstone of wood carved in the form of a ship's boat, and on it the piteous legend of a shipwrecked crew drifting ashore, on a Christmas morning, all frozen to death.

In another manner our troops recently in Thibet, when at a great altitude, were unable to use the machine guns, the frost having set the oil hard.

In the severe winter of February 1895 I noticed in Buckinghamshire a curious circumstance, viz. that some stand-pipes accidentally left with water in them out of doors did not split, but a considerable number which had been *emptied* of their contents did! This I found was due to the pipes being galvanised, and the rates of contraction and expansion between the inner and outer surfaces being different. In the same winter many stems of the more succulent shrubs split lengthways like burst pipes.

The beauty of the fernlike patterns on the window glass and of the forms of frost crystals is well known.

As a side glance at the effects of frost upon trade, I may quote a few words from the last report of the Peninsular and Oriental Steamship Company:—

> Prospects were better than they had been for some time, but an unexpected and altogether abnormal frost in some of the wheat and seed districts of India completely destroyed those prospects, and for several months the cargoes obtained at Bombay and Calcutta were wretched beyond almost all previous experience.

[1] That of the Institution of Civil Engineers.

The Government weather warnings are closely heeded in the fruit gardens of California, where, on a single occasion alone, precautions being taken in due time, several million dollars' worth of produce was saved. Mr. Mawley also, in one of his valuable Phenological Reports, gives an instance of a single owner in Bedfordshire losing £400 worth of potatoes by an untimely frost.

"Stock frosts" ("ice meers," "gru," or "anchor frosts") are comparatively rare, and are only met with when the surface of the river has been exposed to very cold winds lasting for several days, and during severe frost.[1] In these circumstances the usual order is reversed—the surface, being agitated, remains fluid, while the ice forms at the bottom of the river in the still water. The crystals of this subfluminal ice are of different form to those in the surface ice. In the severe Crimean winter this ice was to be seen below the Thames, the Ouse, the Wensum, and other English rivers.

In a glazed frost we have one of our chief outdoor dangers, people and horses being helpless to keep their feet.

With low temperatures we constantly have—

Fog.

The inconvenience, danger, and expense arising therefrom is very great. "London," says John Evelyn, speaking of fog in the winter of 1683-4, "by reason of the excessive coldness of the aire hindering the ascent of the smoke, was so fill'd with the fuliginous steame of the sea-coale that hardly could one see crosse the streetes, and this filling the lungs with its grosse particles exceedingly obstructed the breast so as one could hardly breath." The interruption of business, the delays, the loss to tradespeople by the absence of their customers, and the personal discomfort by the stress upon the lungs, is very great. The death-rate rises both from this cause and also from the large number of accidents out of doors unavoidable at such times. The movements of shipping are arrested or greatly impeded, and railways incur a double expense—for besides the loss of passenger traffic they have a heavy wages bill for fogmen and staff, and have often to put aside great part of their heavy goods traffic for hours in sidings. One of the worst accidents, perhaps, in fog on a railway was that at West Drayton in February 1874—a triple collision between two expresses and a train laden with Bath stone.

Another accident—a road one—was on December 30, 1813, when the London mail reached Berwick-on-Tweed late owing to a dense fog, the horses being led by the driver, notwithstanding whose care the mail coach had been overturned *twice*!

De Quincey relates,[2] with ghastly vividness, one of the historic Ratcliffe Highway murders of 1812 (from which originated the familiar chain to our front doors), which took place in a dense fog, whereby the murderer succeeded in making his escape.

In January 1814 the fog lasted for a week, and, amongst other persons, the Prince Regent lost his way when attempting to pay a visit to Lord Salisbury at Hatfield, and never got farther than Kentish Town.

[1] Mons. Arago has a paper on this subject in the *Annuaire du Bureau des Longitudes* for 1833.

[2] In his "Murder as one of the Fine Arts."

Probably the worst fog of recent years was that in London on the last day of 1888, but the week of fog of "The Black Christmas of 1904" will be still in the memories of all.

Fogs create for the time great strain on the resources of both gas and electric light companies, and also give overtime at the fog-signal factories to replenish the large reserves then heavily drawn upon. At sea great ingenuity has been devoted both to the improvements of the lighthouse lanterns and to codes of signals for ships—the latest development of which has taken the form of submarine signalling.

In 1854 the Collins liner *Arctic* was lost off Cape Race, with over 300 lives, by collision in a fog; and in 1883 the celebrated Inman steamer *City of Brussels* was lost in the same manner off the Mersey.

In a very thick fog in May 1875 the German mail steamer *Schiller* was wrecked off Scilly with a loss of over three hundred lives; and in September of the same year H.M.S. *Vanguard*, one of the ironclads of the Channel Fleet, was sunk in a fog by another ironclad, H.M.S. *Iron Duke*. On one occasion the course of a Holyhead packet was laid across Channel in a fog so accurately that it cut in two and sank the Kish light-vessel, its objective when fifty miles off; and on another, two Dieppe packets crossing in opposite directions were so exactly on their track in a fog that they collided and one *The Seaford* was sunk.

On shore it is at times equally difficult to ascertain one's precise position, hence the number of persons losing their way, and sometimes life also, by walking over the edges of docks, platforms, areas, etc.

An anecdote is told of Dean Buckland, the great geologist, who was caught by a dense fog on his way by coach from Oxford to London. Neither driver nor outside passengers could make out where they were, or if on the right road even. The Dean, when the stoppage had lasted some time, got out himself to investigate, and began poking about along the hedge-side. Suddenly he exclaimed, sniffing and tasting a little piece of soil, "Near Uxbridge, just north of Uxbridge." The coach slowly moved on into the gloom, and very shortly entered the town of Uxbridge.

In the late summer of 1812 the news of Wellington's great victory at Salamanca was received at Plymouth and telegraphed on to London. A thick yellow haze came on in the middle of the message, and broke off the official communication, the first two words of which only reached London that day. "WELLINGTON DEFEATED . . ." Plymouth was a scene of the wildest rejoicing, while the capital was plunged into the greatest consternation, until the next day the semaphore arms became again visible, and the message was completed, "WELLINGTON DEFEATED THE FRENCH AT SALAMANCA, AND," etc.

During the Crimean War the battle of Inkerman, it will be remembered, was fought in a dense fog, and the English warship *Tiger* was captured by the Russians off Odessa in a fog.

Indoors—Mr. Dexter, in his book on *Weather Influences*, states (p. 43) that "during London fogs, and on days when the weather is particularly depressing, in the Bank of England certain sets of books, an error in which would be cumulative and produce disastrous results further on, are locked up, and the clerks set at tasks less intricate and important in character. Experience has taught those in charge that the percentage of errors increases manifoldly during such climatic conditions, and that it

is money in pocket to yield to it. The same necessity for cessation of certain lines of work during bad spells of weather is recognised by the larger banking institutions of New York and the other eastern cities, and a rotation of work in conformity to them is rigidly observed." Unfortunately for Mr. Dexter, however, no one at the Bank of England has ever heard of these precautions, and I fear that the passage just quoted is one more picturesque than accurate.

Continued fog necessarily delays the means of transmission, and curtails the energy of the half-blind, half-choked workers, hence our letters arrive after time, and the Post Office becomes paralysed almost as in modern times on a Bank holiday.

From fog to—

Mist

is an easy transition, though the causes may be widely different. We may have a curtain of white mist preceding a warm day in summer, or a yellowish East wind mist on a hot day in May, followed by a plague of green-fly—the aphis which infests the smaller trees and roses, and another kind also known as "cuckoo spit." Again, we may have wreaths of white steam, apparently, circling up from the ground after a shower in very hot weather when the sun bursts out again.

Another kind of mist may be referred to, happily one not of very frequent occurrence, the blue mist thought to be associated with pestilence, of which Mr. Glaisher gave so vivid a picture in July 1866 :—

> On looking from the grounds of the Royal Observatory at Greenwich I saw the same dense blue mist which has continued without intermission to the present time though somewhat less in density this morning. Ordinary mists pass away when the wind blows with the pressure of half a pound on the square foot. Since last Monday we have had pressure of the wind varying from a quarter of a pound to nine pounds, blowing continually from sixty to seventy hours, yet there has been no change in this blue appearance. I have examined the atmosphere daily for this blueness, particularly during the last twelve months, and have never seen anything like it since 1854. This mist is apparent on all sides ; it extends fully to the top of the trees, though then not so easy to distinguish. It is most discernible through as much atmosphere as possible looking under trees. Thus seen, the boundary walls of Greenwich Park, and all objects near them, are coloured blue ; or through gaps in trees, if there are others at a sufficient distance to form a background, when it resembles thin smoke from a wood fire. The intensity of the blue is increased when viewed through a telescope with a low power. The only other tint of mist I know connected with the prevalence of epidemic is that of a yellow mist, perceptible in like manner when scarlatina is prevalent ; in neither case is there any excess of humidity in the air.

Modern investigation, however, does not bear out this connection between the coloured mists and disease.

Earthquakes,

happily in this country—unless one is furnished with special instruments to detect them—hardly fall within the meteorology of ordinary daily life.[1]

[1] Curiously, a very severe one which happened during the battle at Trasimene in Hannibal's time was not noticed by the combatants themselves in the heat of the engagement, though it caused great devastation in Italy.

It is true that in 1382, while a council was being held in May at Blackfriars to condemn the doctrines of Wyclif, a severe one occurred causing much damage; and in 1580 we find that the earlier cathedral of St. Paul's was injured by an earthquake. In February 1626 a severe one occurred during the coronation of Charles the First at Westminster. Two which happened in February and in March, 1750, created great consternation in London. On the second of these occasions, says Horace Walpole in his *Letters*, "Frantic terror prevails so much that within these three days seven hundred and thirty coaches have been counted passing Hyde Park Corner with parties removing into the country. Several women have made earthquake gowns—that is, warm gowns to sit out of doors—these are of the more courageous." For some weeks a large portion of the fashionable world slept at night in their carriages in Hyde Park, so great was the alarm.

"I remember," says Addison,[1] "when our whole island was shaken with an earthquake some years ago, that there was an impudent mountebank who sold pills which, as he told the country people, were very good against an earthquake."

Time does not now permit reference to the great one at Lisbon in 1755; but one in this country as lately as in April 1884 deserves mention on account of the damage it did, especially in the neighbourhood of Colchester.

In civilised countries, next to the actual destruction of buildings, the chief danger from earthquake is the strain upon the joints of drain-pipes or of gas or water mains. The cases of fracture or serious leakage are readily traceable, but over immense areas it would be impossible to open up and inspect all the minor cases of injury.[2]

The damages in Japan are on an immense scale. On one occasion a single railway was interrupted at no less than eighty-eight points from torsion of rails or viaducts carried away. In June 1896, again, in a great sea wave following an earthquake, no less than 20,000 lives were lost in that country, and 12,000 buildings of various sorts destroyed.

It is significant of the vast correspondence of the British Post Office, that earthquakes should be especially mentioned in the *Post Office Guide* (in the section dealing with registered letters).

Eruptions of volcanoes, such as those of Vesuvius, Mont Pelée (Martinique), and Krakatoa or Tombora in the East Indies, hardly fall within the scope of our survey to-night.

We now come to—

Drought,

any long spell of which is very injurious. The impure dust from the roads in cities and large towns is inhaled or is deposited upon food exposed in shops or stored in cellars or larders, often *below the level of the road*, and the cleaner dust of the country coats the roadside hedges, trees, or shrubs, until many are killed by this choking of their leaf pores. The very air becomes unclean and loaded with irritant particles; and impure germs are wafted for great distances to breed mischief. The first rain itself after a summer drought is no longer pure. The fruit prematurely

[1] In *The Tatler*, No. 240.

[2] That of fire has since been added, at San Francisco in April.

falls off the trees, the larger deciduous trees themselves lose their foliage before the accustomed time, the hay has no bottom to it, and the crops grow short and stunted. The roots of the big trees can be traced underground for long distances by their map-like yellow traces in the turf over them. At Silchester indications of walls, temples, or villas buried beneath have been traceable in dry years in the crops planted overhead. Wheat, geraniums, and lucerne withstand drought best—so do butterflies, beetles, and grasshoppers. Birds, as well as suffering from thirst—especially at breeding time—are short of meat, *i.e.* the worms have left the parched surface of the ground. While good plants are perishing, it is vexatious to observe the longer-rooted weeds flourishing. "Certain poisonous plants[1] also appear to rejoice in the drought. Thus that scarce and most beautiful poison plant, the henbane, with juicy stalks, dark verdant leafage, and pale white blossoms, stands up, as if watered nightly with a baleful dew, among the gasping and thirsty vegetation around it."

In a drought many plants, instead of running as much as usual to green leaf, bear a profusion of blossom. The perfume of the lime and of the mignonette is more fragrant than usual. The wild flowers and poppies, too, are hardy and bear more abundantly. But the succession of vegetables falls off, the root crops—turnips and swedes—languish, and the grass stops growing, and the cattle search discontentedly from patch to patch. The mill streams run short, and the navigation of shallow rivers becomes difficult. The streams nearly dry up, and the fish are imprisoned to almost starve in a few deeper pools.

In 1826, during three very hot months of drought, so short and stunted were the crops that in a large number of instances the sickle was useless—the scythe was employed instead, or else the blades even plucked by hand. The cattle on the burnt-up pastures became poor and starving, and very little hay was obtained for use in the following winter.

Owing to recent shortage of rain the Grand Junction Canal, had not very large sums been spent of late years in improvements at Tring, would have been unable to have carried on its traffic, at least without serious delay.

In times of drought the water both for human beings and cattle has to be conveyed in carts, tubs, or tanks for long distances, and therefore the supply doled out, when a *larger* one is needed, is *less* than usual. The evils of short water allowance need not be dilated on. The river water is diminished in volume in proportion to the solids carried along in it, and in summer, being warm, readily conveys germs. The wells pumped low become thick, and there is little dilution of solids, hence, instead of drinking from the clearer upper water, the supply is drawn from the sediment, and health suffers.

Houses themselves show evidences of drought, in some cases by subsidence when the water is abstracted from the soil below them, and by the shrinking of doors and windows. The prolonged dryness of the season is assigned as a contributing cause for the rapid extension of the great fire among the wooden buildings of London in 1666.

In very dry weather, according to statisticians, there is a considerable increase of crime.

Abroad, it is sufficient to allude to the effects of a dry season on the

[1] Says a writer in *The Spectator* newspaper in August 1905.

Australian wool market, or of a failing monsoon causing famine, such as the great one at Orissa in 1866, and the consequent appalling rise in the death-rate.

We need not recall the *solaria*, or basking chambers of the ancient Romans, or the testimony of Rousseau, Shelley, Byron, Southey, or Charles Lamb, to become persuaded of the happy influence of the

SUNSHINE

which brightens our lives. A doctor will furnish a practical illustration of its tonic effects, and point out how much more rapid is the recovery of patients in a ward on the sunny side of an infirmary to what it is in one on the dark or perhaps shut-in side.

Spring, moreover, is a seed-time for great projects, when the brain is stimulated by the increasing actinic power of the sun after the dormant period of winter.

Each of our so-called health resorts appears to be blessed with the lowest death-rate in the kingdom; without conceding this statistically, we may at once admit the great advantage of a warm, dry, uniform climate in a sheltered position, and, consequently, the great gain to invalids residing on our southern coasts or in especially sunny positions.

The activity of the sun is sometimes unwelcome, as in the change of colour of materials, or in the fading of water-colours or photographs, the drying up of the oil in external paint surfaces, or even occasionally in accidental fires where, say, a match box has been carelessly left in a window near the focussing rays of a water bottle.

So great is the power of the sun that it is able on a summer's day to lift the centre of the long tube of the Menai Tubular Bridge an inch;[1] it also has an influence unfavourable in very bright weather to the passing of wireless messages.

A curious illustration of the sun's power was given in 1900 at the Paris Exhibition. Its rays were focussed by glass to fall upon a small boiler in which steam was generated, and this in turn caused a printing press to revolve.

It transmits a message of its own, the shepherd's warning of the rainbow. A popular error is called to mind by this spectacle. You will be often asked, "Have you seen THE rainbow?" as if more than one person (unless exchanging their positions) could see the same rainbow! Every one sees a fresh or different rainbow according to the angle at which he or she is posted.

Many present will recall the meeting of Lowell on a hot day with a rival meteorologist. "The other day," he says, "I marked 98° in the shade, my high-water mark, higher by one degree than I had ever seen it before! I happened to meet a neighbour; as we mopped our brows at each other he told me that he had just cleared 100°, and I went home a beaten man. I had not felt the heat before save as a beautiful exaggeration of sunshine; but NOW it oppressed me with the prosaic vulgarity of an oven. I might suspect his thermometer (as, indeed, I did,

[1] In his evidence in 1906 on an accident at the South Eastern station at Charing Cross it was stated by the engineer that even the passage of a cloud across the sun was registered by the contraction and expansion of the ironwork.

for we Harvard men are apt to think ill of any graduation save our own), but it was a poor consolation."

Gilbert White's tortoise, too, deserves mention, who, when the sun's rays began to lose power in autumn, used to tilt himself up at an angle against the garden wall, having found out that when at an angle with the plane of the horizon he appropriated more of the sun's rays.

Even outside the limits of the so-called "Black Country," our sunshine is diminishing artificially owing to the growing distance to which smoke is carried from the cities and the large towns. The inrush of population from country to town is increasing this evil, and the factory and electric light and power chimneys are still further adding to it. We welcome, therefore, the work of the Coal Smoke Abatement Society in the amelioration of the atmosphere.

Passing to the effects of the sun we come to

Heat,

the prolonged effect of which at a high temperature is very injurious. In the tropics this is especially so in regard to the liver, the largest organ in the body. In these islands, too, we have on occasion[1] reached a shade temperature of over 100° F.

An American writer (Dexter) points out that abnormal heat, especially in spring and autumn, stimulates quarrelsomeness; and it is of common knowledge that a tired or exhausted individual is more irritable or short-tempered than is wonted. The end of winter brings with it a depleted condition of vitality, both nervous and physical, hence suicides are more frequent in May,[2] the human organisation not then being fully acclimatised to the heat of summer, or the tissues evenly expanded.

Health suffers much in excessive heat, partly because people are very slow to change their habits, or even their style of hats or clothing, or to take, as abroad, a siesta at mid-day; partly by the exhaustion of strength; partly by the deterioration of food, or the use of iced drinks, or the heat of railway carriages.

Severe heat brings in its wake sunstrokes and heat apoplexy (it should be noticed that when in movement there is less danger of heat-stroke than when the body is stationary), summer diarrhœa, hay fever (induced by the dried pollen and dust drawn up and carried in the air), and intensifies the ravages of cholera. Hydrophobia is now fortunately less frequent.

Our food (much of which nowadays suffers all the year round from cold storage and long transit) is spoilt by being kept on ice or in refrigerators; our milk is loaded with boracic acid, to the detriment of our health; vegetables and fruit are liable to ferment, and meat to become putrid or contaminated by flies.

In a very hot season with absence of rain the juices of various fruits become concentrated, and consequently very powerful and even irritant, the juice not being diluted with the customary proportion of water.

[1] The highest recorded temperature in the shade was at Tonbridge, Kent, of 100½°, on July 22, 1868.

[2] The highest records occur on Sundays and Mondays, and happen with most frequency in the afternoon and evening.

The death-rate is increased by the various causes incidental to extreme weather and by ptomaine poisoning.

Trades lose by the swift spoilage of unsold food, by milk turning sour, or by brewing difficulties.

Out-of-door fires from a lucifer dropped by a careless smoker, or from boys playing with matches on the parched grass or bracken-covered commons, are frequent.

The aerated-water factories, artificial-ice companies, and the Luton manufacturers of straw hats, benefit greatly by the rise of the thermometer.

Buildings suffer, especially those with lead roofs. For example, the leaden roof of the choir in the cathedral at Bristol moved no less than eighteen inches in two years. Where the lead was nailed down to stop this movement, the nails themselves were drawn out. Being on a slant, the lead, when expanded, pushed downward in the heat of the day, and, when it contracted at night, it drew down the upper edge of the sheet. Travellers through the Midlands will also recall the curious, much-contorted steeple of Chesterfield Church, twisted by the effects of sun-power upon unripe wood when the covering metal became heated.

Railways, at times of great heat, experience a danger from the elongation of the iron or steel rails (beyond the limits ordinarily provided for); the track is bulged out and the vehicles are derailed.

Though we cannot boast of the fireflies of the Tropics, we can suffer from mosquitoes, and we occasionally see the harmless and pretty glow-worms in hot weather.

We may notice, too, the bark of trees splitting in dry heat, and the cracks appearing in the ground; and a beautiful sight on a hot, dark night—the waves turning over and bursting suddenly for an instant into brilliant phosphorescent fire from the myriads of minute infusoria which the warm water permitted to reach these shores.

The present January being a warm one recalls a singular incident. In January 1662 Dr. Ryves, then Dean of Windsor, preached a sermon at St. Margaret's, Westminster, before the House of Commons, on the subject of the great public alarm caused by the prevalence of midsummer weather at midwinter.

A frequent accompaniment of hot weather are

THUNDERSTORMS,

in which, despite the increasing use of conductors and protectors, great havoc is wreaked by lightning.

The Coronation of Henry the Fifth on Passion Sunday 1413 at Westminster was interrupted by a great thunderstorm.

It is curious to notice the historic coincidence of some thunderstorms. The day the great Napoleon crossed the Niemen to invade Russia was marked by a very severe one; the day he retired from Germany in 1813 by another similar one, though unusual at that season. Again, on two other disastrous occasions for him thunderstorms occurred, at the battles of Quatre Bras and Waterloo in 1815. In the campaigns of Wellington in the Peninsula, we find thunderstorms before the engagement at Sabugal, and one on the eve of the great victory at Salamanca. These

are but coincidences, however, just as one of the Roman Legions had given to it the name of "The Thundering Legion," because the prayers of some Christians in it were followed by so dreadful a storm of thunder and lightning that the enemy (the Marcomanni) were put to rout.

The effects of lightning and huge forest and prairie fires are well known; also the dangers to powder magazines, now very carefully guarded against.[1]

One great danger from the sudden concentration of water occurs too with thunderstorms. To give one example—when the great thunderstorm of July 9, 1846, occurred at Truro, the water rushed down from the hills in huge torrents and poured suddenly into the mine workings. No less than thirty-nine miners were drowned in a few moments.

A singular accident once happened on a railway in Surrey. The signalman sent an electric signal to block the line behind a standing train. A storm was raging over the district, and the electric message was exactly reversed. While his own instrument was pegged at "danger," the corresponding one in the other signal box indicated "line clear," the magnetisation of the needle having become reversed. In consequence of this two trains collided. This led to a very valuable invention by Mr. C. E. Spagnoletti of an undemagnetisable needle for telegraph instruments.

I do not touch upon the danger to human life.[2] It was only last spring that we saw records and examples of this collected under this roof.

In the inanimate world the oak tree appears most frequently struck, owing, doubtlessly, not merely to its length of fibre, but chiefly also to it being one of the deepest-rooting trees. Potato plants are often sufferers from a species of blight during storms, probably induced by sudden change of temperature. If the silence of birds before a thunderstorm is noticeable, the converse is the case with insects, when (according to Kirby's and Spence's *Entomology*) the state of the atmosphere particularly excites insects so much that several of the rarer species were able to be captured only on these occasions.

In the afternoon of March 26, 1827, Beethoven was seized with his last mortal faintness. Thick clouds were hanging about the sky; outside, the snow lay upon the ground; towards evening the wind rose; at nightfall a terrific thunderstorm burst over the city of Vienna, and, while the storm was still raging, the spirit of the sublime master departed.[3]

The palace of the Escurial was three times set on fire by lightning, Merton College, Oxford, injured by it, the railway station at Antwerp damaged by it in 1865, and the (former) Eddystone Lighthouse struck by it in 1853.

The spire of Old Saint Paul's was struck twice by lightning—in 1444 and in 1561; that of Norwich Cathedral twice, once with great damage in 1463, and in 1601; the spire of Ripon Cathedral in 1593;

[1] In August 1765, when the tower adjoining the magazine of the Venetian Republic at Brescia was struck, the whole store of powder ignited and most of the edifices in the town were wrecked. More than two thousand people perished.

[2] In the nineteen years 1835-63 Dr. Buchner states that 6714 persons were struck by lightning in France alone and 2238 were killed.

[3] Haweis' *Music and Morals*, p. 328. The deaths of Cromwell and Napoleon during storms have already been referred to at vol. xxxi. p. 174.

and, in more recent times, the church of St. Martin-in-the-Fields, London, was greatly injured by lightning, and in 1879 the church at Wells in Norfolk was totally destroyed in the night by fire after being struck. Indeed, before the introduction of lightning conductors and bands, such events were very frequent.

Fuller, whose *Church History* appeared during the time of the Commonwealth, refers to the following abbeys and churches being injured or burnt by lightning: Canterbury (twice), Crowland (twice), Peterborough (twice); St. Mary's Abbey, York; Norwich; St. Edmund's, Bury; Worcester, Gloucester, Chichester, Glastonbury, Beverley; St. Mary's, Southwark; and the steeple at Evesham.

Thus in France we find the spires of the cathedrals of Lectoure and of St. Denis burnt by lightning; the (first) north spire of Chartres Cathedral destroyed by it, July 26, 1506; the original tower, of stone, in the centre of the cathedral at Amiens struck and destroyed in 1527; and at Rouen a stone spire of the earlier portion of the cathedral was overthrown by lightning in 1117, and three turrets of the same splendid building were destroyed by lightning, June 25, 1683, while the north-west tower of Troyes fell a prey to the same enemy in 1700. The spire of Strasbourg was also struck. The sacred chronicles of the Jews tell us that the Temple of Jerusalem bristled with iron points, perhaps with intention.

> The very shadows of the clouds
> Have power to shake me as they pass,

wrote Wordsworth, and every cloud brings its

Wind,

some day, perhaps, to be harnessed to our airships when aerial locomotion will be as customary as is to-day the use of motors on land. The service of the wind in grinding our flour is falling into disuse; so, also, the aid of the wind has largely been dispensed with in navigation, but for pumping it is being increasingly used.

A vivid picture of the effects of the absence of wind is given by the Princess Henry of Battenberg in her translation of the Count of Erbach's Life (pp. 73-75)—of the galley slaves worn to skeletons. "How many hours are they obliged to row?" asked the Count. "As many hours as God and the Holy Virgin deny us a favourable sailing wind" was the answer.

We no longer see large fleets of vessels becalmed or windbound in the Downs or in Torbay, or hear of the "weather gauge" in battle manœuvres; but it was owing to an adverse wind that the great Duke of Wellington was sent to Portugal. He had actually, in fact, embarked for service in North America, but his ship was detained by unfavourable wind off St. Helens, when he received fresh instructions which altered the history of Europe. It was by the agency of the wind that Gambetta escaped in a balloon from Paris.

It was to George Hadley, brother of Hadley the astronomer, that we owe the first scientific description of the Trade Winds in 1735.[1] To-day

[1] It is rather startling to find as late as 1618 a Hungarian traveller describing the Isle of Man as being celebrated for having no foundation, and thus being blown hither and thither in the ocean—sometimes as much as sixty miles. (See Martin Zsombor's *Europica Varietas*, published in 1620.)

we are looking to Dr. Shaw for some comparison between the strength of these winds at St. Helena and the amount of the rainfall on the southern coast of England.

The sea, aided by the wind, has robbed us of two cathedrals—Selsey and Dunwich—and the parish church of Whitby is now being gradually undermined.[1] Kentish men will think, too, of Tenterden steeple.

The work performed by the wind is very considerable. It transfers dry powdery soil in large quantities from spot to spot, especially so in the case of the sand dunes such as those piled up in North Cornwall, Arcachon, on the shores of the Baltic, on the fringe of Lake Michigan, etc.; the sand blown up and deposited enveloping even woods and low hills. The inroads made by the sand in Holland in 1107 were exceptionally severe, and consequently a great body of Flemings emigrated to this country and were formed into a colony in Pembrokeshire by Henry I.

The wind wafts many of the lighter kinds of seed through the air to fresh planting ground, that of the thistle among them, an unwelcome arrival. It acts too the part of police in clearing out rotten boughs or by oversetting trees. The storm which, a quarter of a century ago, devastated the playing fields of Eton, will long be remembered, the elms which fell on that occasion were over two hundred years old. From the leaning of the living trees, especially those near the coast, or in exposed positions on hillsides, you can generally recognise, by their bias, the direction of the prevalent wind. It carries away also buildings which have approached their term of life and are so becoming dangerous. It changes the air too when it becomes vitiated or exhausted in courts, alleys, or slums, in the quadrangles of ancient buildings, or in large closely built towns, the difference in the taste of the air the morning after a gale being most noticeable.

"During continuous high winds, however," says an American investigator, "the prevalence of murder, suicide, or misconduct in (the large) schools often amounts to six or eight times what is customary." Horses we all know require much closer attention in windy weather, even veterans.

It was Charles Kingsley who delighted to walk up hill against a North-east wind, and Mr. John Morley has told us[2] of Diderot that "he had a passion for high winds. They gave him a transport, and to hear the storm at night, tossing the trees, drenching the ground with rain, and filling the air with the bass of its hoarse ground tones was one of his keenest delights."

The dry piercing cold of the *Mistral*, which blows southward through the Rhône Valley, in chilling contrast to the geniality of the sunshine, has been described by Madame de Sévigné as "le tourbillon, l'ouragan, tous les diables dechainés qui veulent bien emporter votre château."

High wind is certainly exciting to the heart's action, and East wind, owing to its action on the pores of the skin, is irritant to the nerves. An East wind also has the quality of continuity—a drought, a rain, or a snowstorm (with a tincture of north added) lasts longer from the east.

[1] The Board of Trade returns show that from 1867 to 1900 this country has lost 182,000 acres by the erosion of the sea, even after the land regained from the sea has been taken into account.

[2] *Life*, vol. i. p. 255.

A heavy side wind also causes loss of time to travellers by train,—it is on record that an express train was even brought to a complete standstill once in Anglesea by the force of the wind,—while a gale carries away telegraph poles,[1] delays mail steamers, and the transit of letters on land.

A strong continuing wind causes sea currents (such for example as Rennell's current off the Scilly Isles which Admirals Vernon and Cloudesley Shovel had cause to regret), and when coupled with a rising tide may create serious inundations, as for instance in London, when the Thames overflowed its banks in Bermondsey, etc. (See also page 88 for other instances.)

The blizzards of Canada and North America are fortunately seldom imitated here, and the dust storms so formidable in Africa, and also reaching Malta in diminished force, are happily unknown in these isles, save in a few spots on the actual coast, though some minute traces of African dust, verified by the microscope, have been deposited in the west of England and Wales, carried from so great a distance.

Darwin in his work on Earth Worms refers (page 238) to the dry period of 1827-30 in La Plata, when the quantity of dust transported by the wind was so great, that the appearance of the land was so changed by it that the inhabitants could not recognise the limits of their own estates, and constant lawsuits took place through this action of the wind.

We may hope some day by a sufficiently close and lengthy chain of stations, to obtain the average length of wind tracts at varying velocities, and by means of frequent ascents also to ascertain the usual depths of the air currents.

In the days before Dr. Scott and Dr. Shaw issued their prognostications from Victoria Street, and before the advent of the twin screw or turbine, invaders fared badly at the hands of the wind. The destruction of the fleet of Xerxes on the coast of Greece is well known. William the Conqueror in his invasion of England in the autumn of 1066 was delayed for more than a month by contrary winds. It is true that when Henry II. was engaged in conquering Ireland he was thankful for the stormy western seas, which, lashed by the wind of the tempestuous year of 1171, for nearly six months severed all communication between Ireland and the rest of the world. The reception of the Spanish Armada by the elements on reaching our shores is historic; and in 1688 the fleet of William of Orange was driven back to Holland in October, by storms, before he succeeded in reaching Brixham. General Hoche's fleet when sailing for the conquest of Ireland in 1796, was also dispersed by storms, and only a small portion reached our shores.

In other historic events the wind has played a conspicuous part. In 1666 the great fire of London was spread and augmented by the strong East wind blowing at the time, and in May 1842 the immense fire which laid waste the city of Hamburg, was fanned by high winds for several days. The great fire at Chicago in 1871 ("in which the very bricks were consumed") was carried through the city by a strong South-westerly wind.

[1] The new subterranean telegraph lines, to guard against interruption by wind or snow, are now complete between London and Glasgow on the north, and London and Slough on their way to the west.

A great storm which occurred on St. David's Day, March 1251, is described by Holinshed as having damaged Windsor Castle. The chimney of the chamber "wherin the quene and her children were, was beaten down to dust, and the whole building sore shaken. Oaks in the park were rent in sunder and turned up by the roots, mills with the millers in them, shepherds, ploughmen, and such as were going by the way were destroyed."

The Rev. Thomas Knell wrote (in the sixteenth century) an account "of the hurt down in divers parts of this realm by the terrible tempest of October 20, 1570."

After the hurricane which swept across Europe in September 1658, the next most severe was that of November 1703, known as the "great storm," in which, amongst other devastation, the Eddystone Lighthouse was destroyed (with the engineer Winstanley inside it).

The Bishop of Bath and Wells (the learned Dr. Kidder) and his wife were both killed when in their bed in the Palace at Wells by a stack of stone chimneys being hurled through the roof during the height of the gale. It was on this occasion when Sir Christopher Wren was informed that the steeples of nearly all the London churches were damaged, replied with the rapidity of thought "not St. Dunstan's, I am sure," and the mathematical architect was right, for it was almost the only one entirely undamaged. There was an aperture through the spire for the wind to pass through.

A hurricane in January 1839 wrought great havoc in Ireland and Scotland. The three years 1859, 1860, 1861 were very tempestuous ones.

The terrible storm of October 25, 1859, in the height of which the *Royal Charter* was wrecked on the coast of Anglesea with a loss of close upon five hundred lives, created so much sensation throughout the country that it led to the establishment of public storm warnings issued by Admiral FitzRoy. As an evidence of the extraordinary force of the sea during the severity of the gale, some of the gold sovereigns which formed part of the cargo of that vessel, were found impacted in solid iron among the debris.

One of the most eloquent and graphic accounts of a hurricane ever penned was that descriptive of the narrow escape of Brunel's noble ship, the *Great Eastern* at Holyhead, when the end of the breakwater was swept away by the violence of the same gale, in the columns of the *Times* in October 1859. Twice has Stephenson's viaduct at Penmaenmawr, on the North Wales coast, been carried away by storms, the first time in 1859, and again about twenty years later; and the damage done to the Admiralty pier at Dover, while in course of construction, will be remembered, as well as that to the South Eastern Railway on the beach below the chalk heights, near Dover.

The old Chain Pier at Brighton also fell a victim to the elements.

February 1861 was a wild month. In the second storm of that month a wing of the Crystal Palace at Sydenham, and also the spire of Chichester Cathedral,[1] were carried away. The fall of the Tower at

[1] The construction of this spire was of interest to meteorologists. On account of its proximity to the high winds of the sea, Sir Christopher Wren had placed *inside* it a swinging balance as a counterpoise to the action of the wind externally.

Chichester was largely due to weakness of structure, and the gale was the final cause. Professor Willis gave so graphic a picture of the scene that one is tempted to quote some portion of it.

Divine service in the Cathedral on Sunday [February 17, 1861] was interrupted by the urgent necessity for shoring up the facing of the south-west pier which exhibited fresh symptoms of giving way. The workmen were now employed early and late in desperate attempts to avert the approaching ruin which was continually heralded by new evidences of weakness. Still the men pluckily went on diligently applying shores, struts, and braces while the piers were bulging and cracking. On Wednesday crushed mortar began to pour from the old fissures, flakes of the facing stone fell, and the braces began to bend. Yet the workmen continued to add shoring until 3.30 a.m. in the morning of the next day, *notwithstanding the violent storm of wind which arose in the evening, and beat first on the North-east side of the church, but as night advanced came with unabated force from the South-west.*

On Thursday the 21st even before daylight the work was resumed. Seventy men working with most commendable enthusiasm and courage under very great personal risk, made strenuous efforts to increase the number of shores under and around the tower; for those applied only the night before were bent during the gale, and the danger became more and more imminent. The workmen were only induced to leave the building by the dinner hour. By this time the continual failing of the shores showed too plainly what was inevitable. Warning was given to the inhabitants near the cathedral, and the returning workpeople were stopped. Anxious crowds outside the cathedral enclosure stood gazing upward at the tower, and in less than half an hour the spire was seen to incline slightly to the south-west, and then to descend perpendicularly into the church, as one telescope tube slides into another, the mass of the tower crumbling beneath it. The stones and dust from the tower rushed into the nave, choir, and transepts crumbling as it descended, the bulk in the centre of the church, and the top of the spire broke itself across the abutment of one of the flying buttresses."

Chichester is not the only sufferer among our cathedrals from the ravages of the wind. In a great storm on St. Andrew's Day in 1221 two of the lesser towers of Worcester Cathedral were carried away; in 1548 the spire was blown off the centre tower of Lincoln Cathedral; in 1660 Ripon also lost its spire on the middle tower in a storm; and in 1714 the upper portion of the tower of St. Asaph Cathedral was blown down.

The parapet of fine stone tracery of the Cathedral at Rouen was greatly injured in the hurricane of February 3, 1638, and remains unrepaired to this day as a testimony to the havoc of the wind.

Many of the picturesque wind mills on the Downs in the last century, before modern machinery replaced them, perished by the wind, though actually by fire. If the arms broke loose in a very high gale the friction set up was so great that the bearings heated.

In March 1878 came that sudden but disastrous squall which cost us so many young lives on board H.M.S. *Eurydice.*

Looking abroad we meet with two especially great, out of many, cyclones in Bengal. In October 1864 two hundred vessels were driven ashore in the Hooghly; in November 1867 over a thousand lives were lost in Calcutta alone. In October 1867 occurred one of the greatest

West Indian hurricanes since 1780,[1] or 1819 in which nearly every vessel of the Royal Mail Steam-packet Company among the islands was wrecked or greatly damaged.

In the violent storm of December 28, 1879, the Tay Bridge was blown over, at the time it bore on it a train containing over seventy unfortunate passengers who were drowned.

In 1889 a tornado in America carried away the suspension bridge across the Niagara Falls.

The greatest speed of the wind near the earth has been estimated as just exceeding one hundred miles an hour, but its almost instantaneous variability outstrips the ability of the recording instruments to gauge it.

The rocking of towers in a high gale is a matter more for architects than meteorologists: the tower of Antwerp Cathedral, the spire of Salisbury Cathedral, and the exposed lighthouse of St. Mary's in the Scilly Isles have each been observed in movement in gales of wind; and one of the most beautiful and ordinary sights in a high wind is to observe how gracefully elm trees, particularly when in foliage, balance themselves, curving to elude the greatest stresses and keeping in rhythmical movement.

WHIRLWINDS of a very destructive character are fortunately of comparatively rare occurrence. Perhaps the worst one was that of August 19, 1845, at Rouen, where in a few seconds three factories were reduced to ruins, and over two hundred persons were killed or wounded, and the whole of the adjoining valley became a scene of desolation.

The whirlwind at Limerick in October 1851 was also a very destructive one.

The havoc caused by

HAILSTORMS

is often so great that of late years it is necessary, as well as possible, to insure crops against it. The destruction in May, also, when the cherry orchards are in full bloom is frequently very serious.

A hailstorm of great severity took place in Lancashire in April 1697, which is described in *Philosophical Transactions*, and another of great violence in Durham in July 1792, when the corn was cut through and the leaves rent from the trees. 1792 was a very cold summer, and in June a waterspout took place in the Cheviot Hills; also a discharge of hailstones of extraordinary size, which remained on the ground for two or three days mixed with snow.

The greatest hailstorms of recent years have been those of August 1, 1846, and nearly at the same date in 1879.

The first storm was very destructive in London. The glass in the picture gallery of Buckingham Palace was totally destroyed and the gallery flooded. Seven thousand panes of glass were broken at the Houses of Parliament, three hundred at Old Scotland Yard Police Office, and ten thousand panes at Burford's Panorama in Leicester Square. The glass

[1] At the beginning of October: "So completely converting Barbados into a desert that the Governor reported that he did not believe ten houses remained on the island, and causing even greater destruction in Jamaica where an earthquake was added to the horrors of the tempest, and falling on the fleets and squadrons in these waters with irresistible fury. Many of the finest ships went down before it, crews and all, in the open sea, others were wrecked with loss of part of their crews, and scarce one vessel was left for service without undergoing an entire repair."—Yonge's *History of the British Navy*, vol. i. p. 368.

arcade then covering the side-walks in Regent Street was destroyed, and the Surrey Theatre was flooded.[1]

The second storm—the most magnificent in our time for the display of incessant lightning—took place on August 2, 1879. The hail was very large and plentiful, and destroyed nearly all the market gardeners' glass-houses in the Thames valley, especially in the neighbourhood of Richmond, Surrey. A piece of ground on the Twickenham side of the river remained deeply pitted by the stones for a month or two.

An Australian Member of Parliament describes a tremendous fall of hail in New South Wales on the afternoon of September 21, 1867. Hail-stones were picked up, he says,[2] too large to go into an ordinary tumbler. The corrugated iron roof of his gardener's cottage was perforated in several places by the downfall of these icy stones.[3]

In Switzerland upright poles with copper wire attached to them, planted about 80 feet apart, called paragrêles, are in use to protect the vineyards.

Weather Changes.

Besides warnings by telegraph from a distance, or by the instruments on the spot, we notice by the eye the movements of the upper clouds—or smoke lying low, or the greater visibility of the air before rain. So also the song of the lark heard in rain is sure presage of immediately improving weather. Linnæus always regarded the humming sound of the Geotrupes beetle, if heard overnight, as a certain prognostic of a fine day to follow. Sensitive persons at change of weather complain of pains in rheumatic joints, or shooting of corns, etc. Furniture will creak, and slate steps darken in colour with moisture.

In Mexico warnings are issued by the Post Office—the postmark outside each letter bearing a succinct message of what each day's weather is expected to be, in accordance with the forecast of the Director of the Meteorological Department; but this would not be feasible in England, where the postmarks are generally the least legible of any to be met with in Europe. In America weather targets are attached to trains, conveying thereby intimation of expected weather.

Very sudden changes of tension are injurious to health; for example, the illness following the sudden break-up of a long frost.

The foregoing hurried survey of some portions of the vast field of Meteorology cannot fail to bring home, however imperfectly, some conception of how closely the variations and effects of weather appeal to every one. Hence the advantage to be derived by all who may give a closer attention to the subject—and it is for the purpose of furthering the pursuit of meteorology that this Society was founded. If among the audience to-night there are any present who are not already Fellows of the Society, but who may be desirous of being enrolled on our List, I hope they will communicate with the Secretary.

[1] A description of this storm, by Prof. Hunt of the School of Mines, will be found in the *Athenæum* of August 8, 1846.

[2] In *Notes and Queries*, May 19, 1887, p. 409.

[3] See also *Quarterly Journal of the Royal Meteorological Society*, vol. xx. pp. 31-43, for record of further notable hailstorms.

In the Egyptian Book of the Dead one of the ancients, among his redeeming merits, declared that he had "not inflicted long lectures" on his hearers. You will, I fear, deny me this merit unless I at once sit down.

*** *The illustrations accompanying this paper appear by the courtesy of Mr. Hyde, author of "The Royal Mail"; of Messrs. Macmillan and Co.; and also of the Proprietors of the "Illustrated London News."*

Meteorological Work at the Royal Observatory, Greenwich, 1905.

The meteorological observations by eye and by self-recording instruments have been maintained as usual, and the special observations of clouds on selected days in each month have been continued at the request of the International Balloon Committee, a Fineman Nephoscope having been used for this purpose.

Daily reports have been issued as in previous years, weekly meteorological returns furnished to the Registrar-General, monthly returns of temperature, rainfall, and sunshine to the Society, and quarterly reports to the Meteorological Office.

The temperature of the air ranged between 87°·2 on July 26 and 19°·5 on January 1. The mean temperature for the year was 49°·7, being 0°·2 above the average for the 50 years 1841-1890. Three months—February, March, and July—showed mean temperatures well above the average, by 2°·9, 3°·4, and 3°·6 respectively; while October was exceptionally cold, 4°·2 below the average, nearly the coldest October in 65 years.

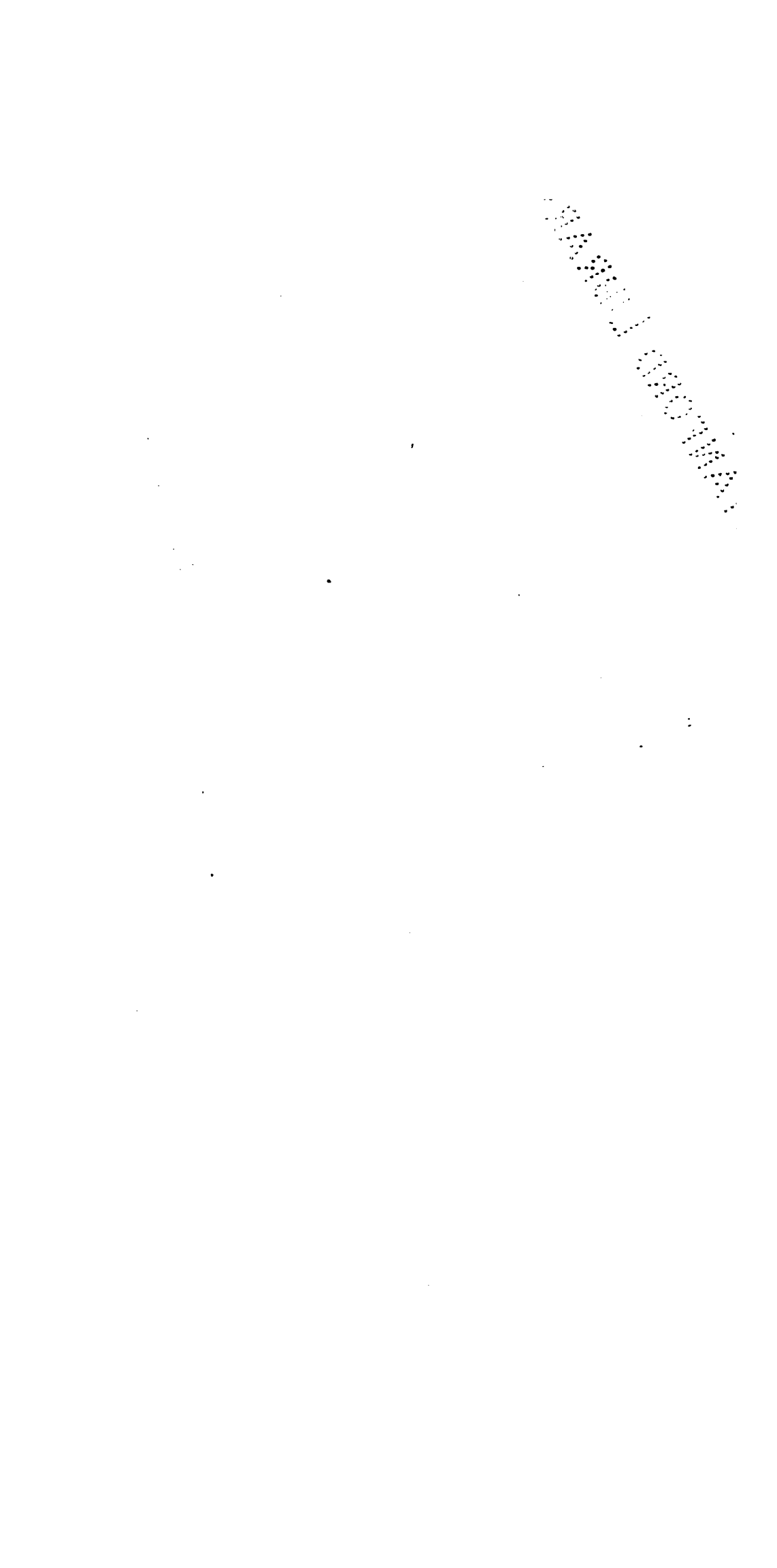
The sunshine recorded in the year amounted to 1420 hours out of a possible duration of 4459 hours, giving a percentage of nearly 32 for the year, and a total 32 hours greater than the average value for the years 1887 to 1904, excluding the years 1894 to 1896, when the sunshine ball was proved to have been defective. No sunless day occurred in May or July, and only one, that of the Solar Eclipse, in August. The longest register for a single day was 14·3 hours on July 3, 14·2 hours being registered both on May 17 and June 23; but the highest percentage of possible sunshine was 91 per cent on May 17.

The highest reading of the Solar Radiation Thermometer with blackened bulb *in vacuo* was 155°·7 on July 27, and the lowest readings on the grass were 9°·8 on January 1, 10°·0 on January 2, and 13°·2 on November 22; another unusual reading being 33°·5 on August 2, a day which also showed the highest reading for the month, 145°·8, of the Solar Radiation Thermometer.

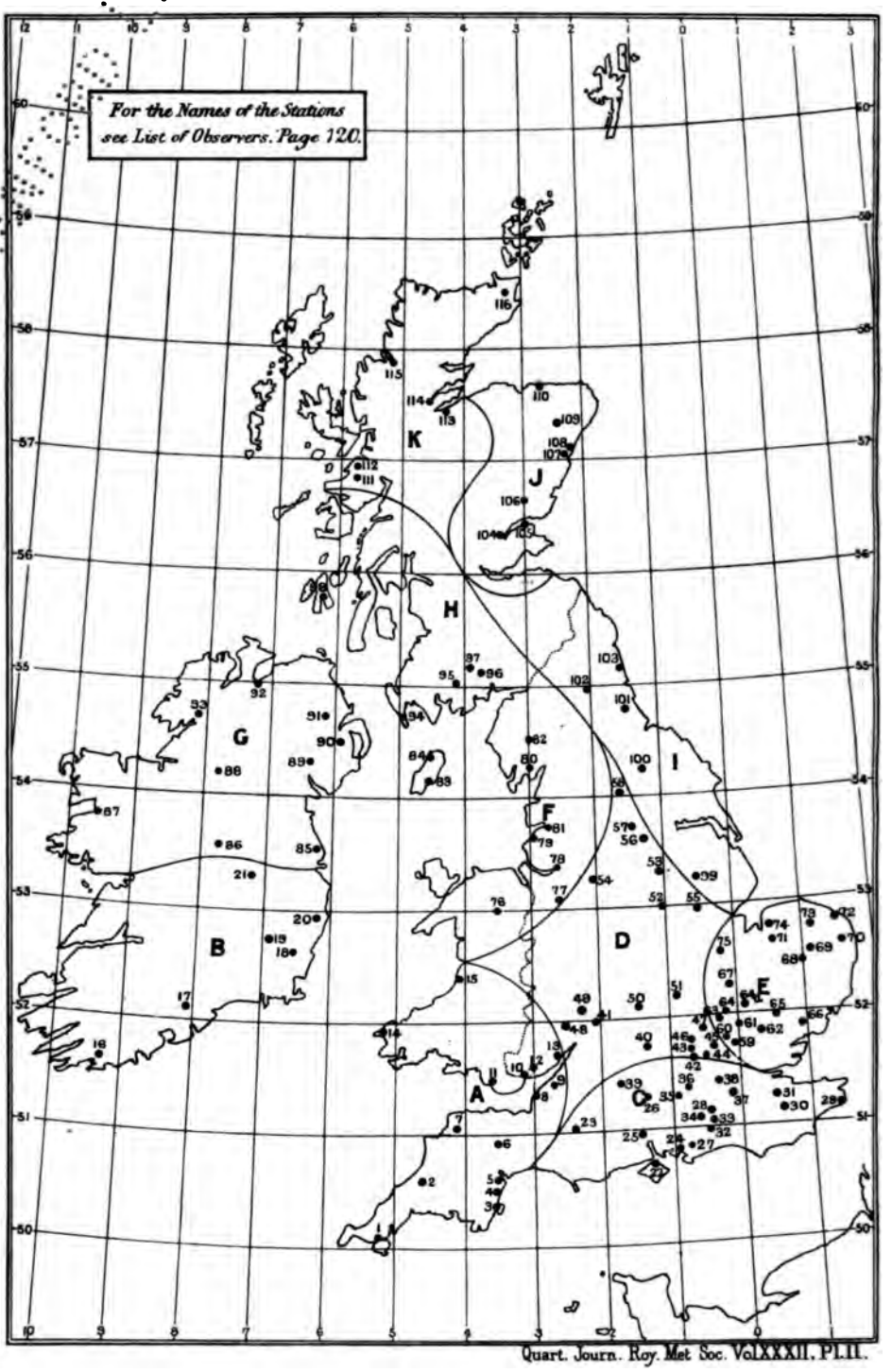
Rain fell on 161 days in the year to the total amount of 23·024 ins., being 1·514 in. less than the average for the 50 years 1841-1890; less than half the average amount being measured in February, July, October, and December, and more than double the average amount in March and June, the wettest days being June 5, with 1·080 in., and March 15, with 0·933 in.

The greatest recorded pressure of the wind was 23·5 lbs. to the square foot on March 12. The greatest daily velocity was 719 miles on November 27, the next greatest being 710 miles on March 11, and the least 69 miles on December 11. The greatest hourly velocity was 44 miles on November 26 and 27. The total movement for the year was 107,583 miles, the monthly amounts being greatest in February and March and least in July and December.

Parhelia were observed on March 10 and April 29, Paraselenæ on January 13, and Aurora Borealis on November 15.—W. H. M. CHRISTIE, March 16, 1906.



MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1905.



REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1905.

By EDWARD MAWLEY, F.R.Met.Soc., V.M.H.

(Plate II.)

[Read February 21, 1906.]

THE following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Castleton in District **A**; Killarney in District **B**; Fordingbridge and Oxshott in District **C**; Watford (The Platts), Leominster, Thurcaston, and Sheffield in District **D**; Symons Hyde and Sproughton in District **E**; and Duror in District **H**. On the other hand, new stations have been started, or old ones revived, at Skibbereen and Tallow in District **B**; Woolton Hill and Purley in District **C**; West Malvern in District **D**; Manley and Preston in District **F**; and Forgandenny, Newport, and Turriff in District **J**. The total number of observing stations is now 117.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE 15 YEARS' AVERAGE (1891-1905), FOR THE THIRTEEN PLANTS IN THOSE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVATIONS TO WARRANT COMPARISONS BEING MADE.

Years.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+10	144	+ 9	150	+11	147	+10	150	+ 6
1892	139	+ 5	138	+ 3	144	+ 5	143	+ 6	147	+ 3
1893	118	- 16	122	- 13	125	- 14	123	- 14	128	- 16
1894	126	- 8	130	- 5	135	- 4	127	- 10	137	- 7
1895	139	+ 5	138	+ 3	141	+ 2	138	+ 1	144	0
1896	125	- 9	128	- 7	132	- 7	130	- 7	134	- 10
1897	130	- 4	132	- 3	136	- 3	132	- 5	142	- 2
1898	133	- 1	135	0	138	- 1	136	- 1	141	- 3
1899	136	+ 2	136	+ 1	141	+ 2	138	+ 1	145	+ 1
1900	142	+ 8	141	+ 6	144	+ 5	143	+ 6	152	+ 8
1901	138	+ 4	139	+ 4	141	+ 2	139	+ 2	144	0
1902	139	+ 5	140	+ 5	145	+ 6	142	+ 5	152	+ 8
1903	134	0	134	- 1	137	- 2	134	- 3	145	+ 1
1904	139	+ 5	139	+ 4	142	+ 3	140	+ 3	149	+ 5
1905	133	- 1	135	0	138	- 1	136	- 1	144	0
Mean	134	...	135	...	139	...	137	...	144	...

Explanation of the Dates in the Tables.

1- 31	are in January.	182-212	are in July.
32- 59	,, February.	213-243	,, August.
60- 90	,, March.	244-273	,, September.
91-120	,, April.	274-304	,, October.
121-151	,, May.	305-334	,, November
152-181	,, June.	335-365	,, December

The averages with which the mean dates of the different plants are compared in Table IV. have been obtained from the actual observations made during the 15 years 1891-1905 in all those districts where sufficient observations were available. Those for the two remaining districts are as near approximations to the true averages as the limited number of records will allow.

The Winter of 1904-5.

Taken as a whole this proved a warm winter in all parts of the British Isles except the north-west of England, where the mean temperature, owing to the coldness of December in that district, comes out about seasonable. It was also in all parts of the country, except the north of Scotland, a very dry winter. Throughout England there was an unusually good record of sunshine, but in Ireland and the greater part of Scotland the total duration fell short of the average.

Owing to the very favourable character of the preceding autumn all tillage operations on the farm were unusually forward at the beginning of this winter. The land, however, had by that time become somewhat too dry, so that a change to wet weather in the early part of December was welcomed, as it moistened the ground and made it firm round the young wheat, at the same time improving the splendid crop of swedes and turnips. After the middle of that month a return to dry conditions took place, which may be said to have lasted throughout the rest of the winter. No sooner was February entered upon than the sowing of spring corn began and proceeded without interruption under singularly favourable conditions—thus affording the early sown spring wheat, oats, and barley as good a seed bed as the corn planted in the previous autumn. Even in Scotland a good deal of corn had been got in before the end of the winter. The autumn-sown wheat and oats continued to improve, and, owing to the limited amount of rain and the occasional frosts in January, never became what is termed "winter proud." The mild and dry weather, together with the plentiful supply of roots, favoured the sheep and cattle, which are reported from all districts to have continued throughout the winter unusually healthy. The only drawback to this season, and particularly was this the case in the north of England, appears to have been the scarcity of water in the ponds, on account of the scanty rainfall.

The keen frost in October and towards the end of November destroyed in most gardens nearly all the flowers then out. Consequently, there were fewer "survivals" from the autumn than usual in the early part of the winter.

The winter supply of green vegetables, favoured by the mild season, has seldom held out as well. It was also an exceptionally favourable winter throughout for planting fruit and other trees and for the cultivation of the ground for spring sowing. Such early flowering plants as the winter aconite, snowdrop, and crocus came into flower in advance of their usual dates.

The fertile flowers on the hazel, taking the country as a whole, made their appearance four days earlier than usual, while the coltsfoot was two days early.

The song-thrush was first heard after the beginning of January, seven days in advance of its average date.

The Spring.

March was a warm month throughout, while April proved cold, and May very variable in temperature, but on the whole warm. In all but the north-east of England, March was very wet, whereas in April the rainfall was about seasonable, and in May very light. There was a very poor record of sunshine in April, but March and May taken together were, except in the north-east of England and the east and north of Scotland, sunny months.

At the beginning of the season the cultivation of the land for spring sowing was remarkably forward, and a deep and fine tilth was obtained with little labour. Indeed, all went well until about the middle of March, when the heavy and continuous rainfall brought all farm work for a time to a standstill. With a return to dry weather sowing was resumed in some districts, but in others little further progress was made until the middle of April, owing in the first instance to the saturated condition of the ground, and afterwards to cold and showery weather in the early part of that month. So that those farmers who were able to take advantage of the singularly favourable condition of the soil in February (and a very large area was planted during that month) got in their spring wheat, barley, and oats unusually early and remarkably well. Whereas all spring corn sown after the middle of March was got in late, with more or less difficulty, and in not nearly as satisfactory a seed bed. The long spell of dry weather in May came as a welcome change, as it favoured the completion of spring corn sowing, while allowing uninterrupted progress to be made with the drilling of mangolds, swedes, and turnips. On the other hand, for the late sown spring corn, and also for the recently planted seeds, the dry period lasted too long. In fact, in many parts of the country for several weeks together scarcely a drop of rain fell. At the end of April there was every promise of a good hay crop, but the month of May, which is said to "make the hay," proved so dry and the nights so cold that the grass, and particularly the undergrowth, received such a check that all prospects of a bountiful hay harvest were soon at an end. Taking the season as a whole, it proved almost everywhere a trying one to all farm crops except the autumn-sown corn and early sown spring wheat, which withstood both the warm and wet and the cold dry periods remarkably well. Potatoes were planted in good time and under good conditions, but the early varieties were in many cases cut to the ground by the exceptionally severe frost of May 23.

As had been the case on the farm, the sowing of spring seeds in the garden was late, on account of the saturated state of the ground in March, and only moderate growth was afterwards made owing to the coldness of the soil in April and the long period of dry weather in May. In nearly all districts there was a splendid show of blossom on the fruit trees, but unfortunately nearly the whole of it was in most places destroyed by the May frosts and cold winds.

Until about the beginning of May the spring plants on the list flowered earlier than usual, the wood anemone being 4 days early, the blackthorn 2 days early, and the garlic hedge-mustard 5 days early,

whereas the horse-chestnut was 3 days late, and the hawthorn 2 days late.

Of the spring migrants included in the Report the swallow and nightingale were both 2 days early, while the cuckoo arrived at its average date, and the flycatcher 5 days late.

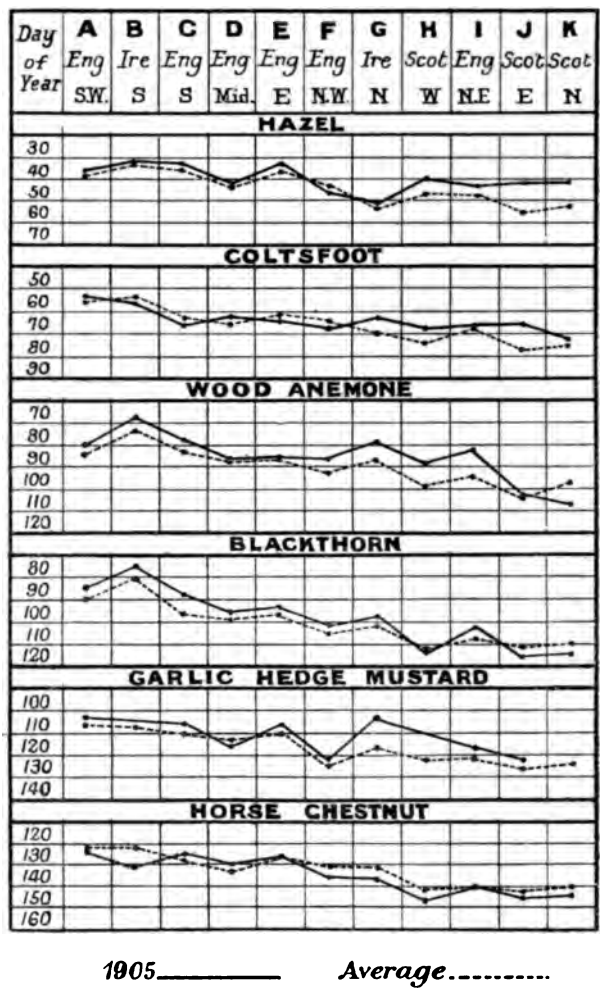


FIG. 1.

The honey-bee was first seen to visit flowers 4 days before its usual time, but the wasp and small white butterfly were both 6 days late, and the orange-tip butterfly 3 days late.

The Summer.

This was on the whole a warm summer—June being moderately warm and July very warm in all parts of the British Isles, while August

proved in nearly all districts more or less unseasonably cold. The rainfall in July was everywhere deficient, whereas the other two months of the season were in most parts of the country rather wet. The record of bright sunshine varied considerably, but in all except the three earlier districts the mean duration for the quarter was exceeded.

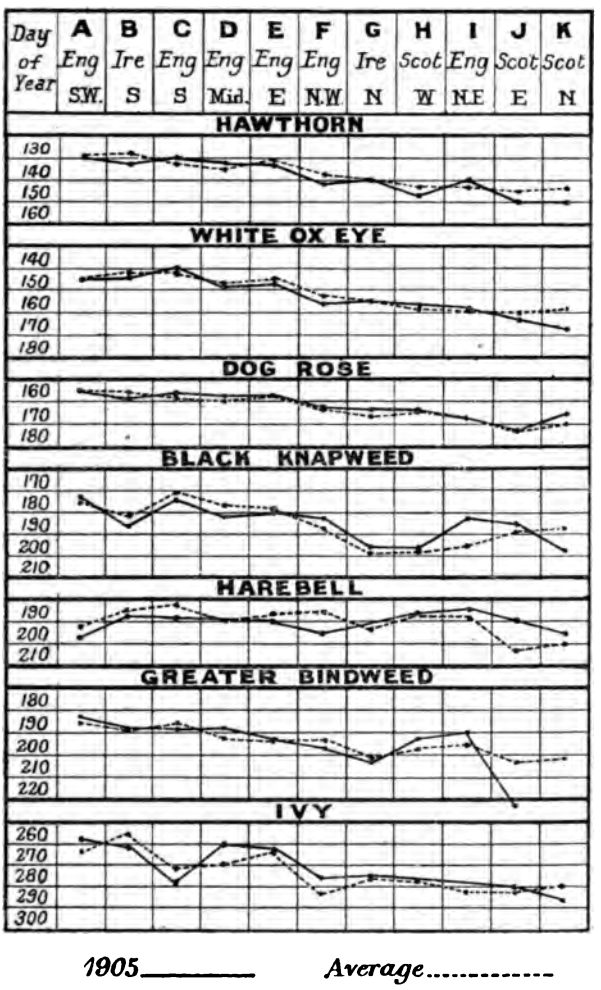


FIG. 2.

The heavy rains at the end of May and beginning of June came too late to materially improve the prospect of the hay crop, but proved of great service to the pastures and roots, and also to the late sown spring corn. The yield of hay from meadow grass was almost everywhere light, but was harvested, as a rule, in excellent condition. The hay from clover and grass seeds was also well secured and yielded a better crop, as it suffered less than the permanent grass during the May drought. So that

this "dripping June," if it did not "bring all things in tune," as it is said to do, at all events improved as far as was then possible the prospects of all farm produce. The long continuance of hot weather in July and the scanty rainfall greatly hastened the ripening of the corn. The wheat, which had been good all through, was benefited by the continued warmth of that month, also the early sown barley and the potatoes, but it had the reverse effect upon the late sown spring corn and the roots—which in the case of turnips and swedes had in many instances to be resown, and often several times before a crop could be obtained, and even then the plants were very irregular. The early harvest weather proved remarkably propitious. The corn crops were, as a rule, short in the straw, but stood up well owing to the straw itself having become so well matured. Consequently harvest operations proceeded rapidly, and a great deal of corn was soon got in under the most satisfactory conditions. Up to the end of the summer no material injury had been done to the grain by the rainy period which set in during the latter half of August. In the north of England the hay harvest was more closely followed than usual by the ingathering of the corn. In Scotland the weather conditions were on the whole very similar to those in the south, until September and October.

The growth made in the garden was less than is usual during the summer, but on the whole this was a gay and satisfactory season. The show of bloom in the flower garden was particulary good during the greater part of July, but the dry weather in that month checked to a certain extent the progress of vegetables in the kitchen garden.

All the summer-flowering plants on the list blossomed at about their usual time, the white ox-eye and greater bindweed being 1 day late, the dog-rose and black knapweed 1 day early, while the harebell flowered at its average date.

The meadow brown butterfly made its appearance 5 days later than usual.

The Autumn.

Each month of this season proved cold, and especially was this the case in October, when the departures from the average in mean temperature ranged from – 2°·0 in Ireland north to – 5°·0 in the southern counties of England. This was not only a cold but also a dry autumn. The duration of bright sunshine was in most districts in excess of the mean.

Until the middle of September the weather remained throughout a great part of the country very wet, while the winds were at times very high, and in consequence the corn still in the fields was to a certain extent injured, particularly barley and oats in the north of England and in Scotland. But only in the late districts in Scotland did the wet weather last sufficiently long for the damage done to be at all serious. Fortunately, in all the earlier districts the bulk of the corn had been harvested before the wet period set in. This was again a fine autumn for wheat sowing, although not as perfect in that respect as the same season in the previous year. For during a great part of October the ground was rather too dry, and on the other hand during November often too wet. So that at the end of the season there still remained a good deal of corn land as yet unsown. Notwithstanding the unseasonable coldness of the weather

in all the three months of the autumn the root crops, assisted by the timely rainfall, made surprising progress, although in but few places was there a full crop of either swedes or turnips. On the other hand the individual roots were as a rule larger than usual. The grass in the pastures also improved, but was at no time really good, owing to the continued low night temperatures. The main crop of potatoes made good progress, but the weather at the end of August and in November caused disease in many places to set in. The potato disease, however, appears to have been very variable, in some cases doing much injury to the crop, while in others the tubers were only slightly affected, and in others again not diseased at all.

All went well in the gardens until after the middle of October, when there occurred several unusually severe frosts for so early in the autumn, which destroyed most of the blossoms then out in the flower garden, while the general coldness of the season checked the growth of the vegetables in the kitchen garden.

The only autumn plant on the list, the ivy, came into flower at its average date.

Taking the country as a whole the last swallow took its departure 4 days later than usual.

According to the *Preliminary Statement* for Great Britain, issued by the Board of Agriculture, the yield per acre of wheat exceeded the average for the previous 10 years by 2·22 bushels, barley by 1·09 bushel, beans by 4·62 bushels (greater than in any year since 1890), potatoes by 0·35 ton, turnips and swedes by 0·86 ton, mangolds by 2·00 tons (only three times greater in the preceeding 20 years), and hops by 5·57 cwts.—thus making it the largest crop of hops since 1886. On the other hand, oats fell short of the average by 0·65 bushel per acre, peas by 0·59 bushel, hay (permanent pasture) by 1·52 cwt., and hay (clover, etc.) by 0·17 cwt.

The heavy wheat crop in 1905 serves to confirm the conclusion at which Dr. Shaw had last year arrived, viz. that there was a very close connection between the character of the autumn rainfall and the yield of wheat in the following year. For, as stated in my last report, "in all the three autumn months of 1904 there was a deficient rainfall—the deficiency ranging from – 3·1 ins. in Ireland south to – 4·8 ins. in Scotland east." For the purposes of this paper I have consulted a very large number of farm reports from all parts of the country, and have been much struck by the fact that although the adverse weather conditions of the year are stated to have injured in some way or another the prospects of all the other crops, that of wheat is almost invariably described as presenting a satisfactory appearance from sowing time till harvest, and to have remained throughout the farm crop of the year. This only shows how necessary it is for a deep-rooting plant like wheat to obtain at the start a firm root hold of the ground, and that having obtained this, how independent it becomes of all ordinary weather changes which may follow.

Taking the British Isles as a whole the corn harvest began 10 days earlier than the average date for the previous 16 years.

The yield of fruit was very poor, the crops of apples, pears, and plums being almost everywhere much below average. On the other

TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
A			
1. Mawnan	Cornwall	200	Miss R. Barclay.
2. Altarnon	Cornwall	600	C. U. Tripp, M.A., F.R.Met.Soc.
3. Brixham	Devon	40	F. W. Millett.
4. Paignton	Devon	70	Miss M. Waite.
5. Starcross	Devon	50	P. G. Waterfield.
6. Tiverton	Devon	270	Miss M. E. Gill.
7. Barnstaple	Devon	90	T. Wainwright.
8. Sidcot	Somerset	200	W. F. Miller.
9. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
10. Penarth	Glamorgan	120	G. A. Birkenhead.
11. Bridgend	Glamorgan	90	H. J. Randall, Junr.
12. Little Mill	Monmouth	300	W. J. Grant, F.R.H.S.
13. St. Arvans	Monmouth	360	Miss M. Peake.
14. St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
15. Aberystwith	Cardigan	30	J. H. Salter, D.Sc.
B			
16. Skibbereen	Cork	30	The late J. J. Wolfe.
17. Tallow	Waterford	...	Mrs. H. C. Deane.
18. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc., F.L.S.
19. Bagenalstown	Carlow	290	Miss F. S. Wynne.
20. Ovoca	Wicklow	110	Miss W. F. Wynne.
21. Geashill	King's County	280	Rev. Canon Russell.
C			
22. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
23. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
24. Havant	Hants	30	H. Beeston.
25. Botley	Hants	30	Lady Jenkyns.
26. Woolton Hill	Hants	...	S. Bramley.
27. Birdham	Sussex	10	A. J. Nixon.
28. Muntham	Sussex	250	P. S. Godman, F.Z.S.
29. Dover	Kent	150	F. D. Campbell.
30. Staplehurst	Kent	110	Rev. J. S. Chamberlain.
31. Maidstone	Kent	100	Mrs. Silcock.
32. Chiddingfold	Surrey	230	Admiral Maclear, F.R.Met.Soc.
33. Cranleigh	Surrey	180	Miss H. E. Ravenscroft.
34. Coneyhurst	Surrey	600	J. Russell.
35. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
35. Churt	Surrey	300	C. Criddle.
36. Bagshot	Surrey	230	W. Burgess.
37. Purley	Surrey	350	J. E. Clark, F.R.Met.Soc.
38. Weston Green	Surrey	30	H. T. Potter.
39. Marlborough	Wilts	480	E. Meyrick, F.R.S.
D			
40. Oxford	Oxford	200	F. A. Bellamy, M.A., F.R.A.S.
41. Beckford	Gloucester	120	The late F. Slade, F.R.Met.Soc.
42. Harefield	Middlesex	340	G. E. Eland.
43. Chesham	Bucks	300	Miss G. Keating.
44. Watford	Herts	270	Mrs. J. Hopkinson.
45. St. Albans (Worley Road)	Herts	300	H. Lewis.
45. St. Albans (New Farm)	Herts	400	Miss A. Dickinson.
46. Berkhamsted	Herts	400	Mrs. E. Mawley.
47. Harpenden	Herts	370	J. J. Willis.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
48. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
49. West Malvern	Worcester	600	Mrs. Kensington.
50. Farnborough	Warwick	520	Miss D. J. G. Prater.
51. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
52. Beeston	Notts	210	G. Fellows.
53. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
54. Macclesfield	Cheshire	500	J. Dale.
55. Belton	Lincoln	200	Miss F. H. Woolward.
56. Altofts	Yorks (W.R.)	120	H. G. Townsend.
57. Horbury	Yorks (W.R.)	210	W. Rushforth.
58. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
59. Broxbourne	Herts	120	Rev. H. P. Waller.
60. Hatfield	Herts	380	Miss R. Blackett.
61. Hertford	Herts	140	W. Graveson.
62. Sawbridgeworth	Herts	350	H. S. Rivers.
63. Hitchin	Herts	220	A. W. Dawson, M.A.
64. Odsey (Ashwell)	Cambridge	260	H. G. Fordham.
64*a*. Shelford	Cambridge	60	C. E. Smith.
65. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
66. Lexden	Essex	90	S. F. Hurnard.
67. Roxton	Beds	...	E. B. Day.
68. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
69. Tacolneston	Norfolk	190	Miss E. J. Barrow.
70. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
71. Southacre	Norfolk	100	Rev. E. T. Daubeney.
72. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
73. Hevingham	Norfolk	...	Major Marsham.
74. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
75. Peterborough	Northampton	30	J. W. Bodger.
F			
76. Palé	Merioneth	600	T. Ruddy.
77. Betley	Stafford	250	Miss M. L. Hodgson.
78. Manley	Cheshire	...	Miss C. N. Harrison.
79. Birkdale (Southp't)	Lancashire	40	E. J. B. Sopp, F.R.Met.Soc.
80. Preston	Lancashire	50	J. R. Charnley, F.G.S., F.Z.S.
81. Lake Side	Lancashire	210	Miss L. Burton.
82. Ambleside	Westmoreland	260	Miss L. Armitt.
83. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
84. Orry's Dale	Isle of Man	70	Miss A. M. Crellin.
G			
85. Ardgillan	Dublin	210	J. Woodward.
86. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
87. Westport	Mayo	10	J. M. McBride.
88. Chanter Hill	Fermanagh	250	The Dean of Clogher.
89. Loughbrickland	Down	350	Rev. Canon Lett.
90. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
91. Antrim	Antrim	70	Rev. W. S. Smith.
92. Altnafoyle	Londonderry	450	T. Gibson.
93. Milford	Donegal	150	Miss Osborne.
H			
94. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson
95. New Galloway	Kirkcudbright	450	T. R. Bruce.
96. Jardington	Dumfries	100	J. Rutherford.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
97. Moniaive	Dumfries	350	J. Corrie.
98. Port Ellen	Isle of Islay	10	T. F. Gilmour.
I			
99. Doddington	Lincoln	90	Rev. R. E. Cole.
100. Thirsk	Yorks (N.R.)	120	A. B. Hall.
101. Durham	Durham	350	Prof. R. A. Sampson and F. C. H. Carpenter.
102. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
103. Blyth	Northumberland	20	S. Dunnett.
J			
104. Forgandenny	Perth	...	D. Nicoll.
105. Newport	Fife	160	M. Hardy, D.Sc.
106. Kirriemuir	Forfar	250	T. M. Nicoll.
107. Durris	Kincardine	420	A. Macdonald, M.A.
108. Aberdeen	Aberdeen	40	P. Harper.
119. Turriff	Aberdeen	...	R. Grant.
110. Fordyce	Banff	80	J. Ingram.
K			
111. Invermoidart	Inverness	60	S. M. Macvicar.
112. Roshven	Inverness	40	H. Blackburn.
113. Beauly	Inverness	60	A. Birnie.
114. Dingwall	Ross	10	J. P. Smith, M.D.
115. Inverbroom	Ross	50	Lady Fowler.
116. Watten	Caithness	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations. Plate II.

hand, the yield of raspberries, currants, gooseberries, and strawberries was moderately good.

The Year.

As affecting vegetation, the weather of the phenological year ending November 1905 was chiefly remarkable for the dryness and mildness of the winter months, the drought and frosts in May, the long spell of hot and dry weather in July, and an exceptionally cold period in October. Wild plants came into flower a few days earlier than usual until about the beginning of May, after which time they were, as a rule, to about the same extent late. Most of the early spring migrants, such as the swallow, nightingale, etc., reached these shores rather in advance of their average dates. The best farm crops of the year were those of wheat, beans, and hops; while barley, potatoes, turnips, and mangolds were all more or less over average. On the other hand, the yield of oats, peas, and hay was almost everywhere deficient—the latter being the worst crop of the year. Apples, pears, and plums were in all parts of the British Isles below average, whereas the small fruits, as a rule, yielded moderately well. Taking the farm crops alone, the past year must be regarded as having been, on the whole, a fairly bountiful one.

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1905.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Mawnan	47	73	84	84	...	120	137	...	170	194	...	...	262
Altarnon	51	70	101	107	112	130	150	166	172	193	205	214	...
Brixham	...	74	...	77	...	119	130	143	153	...	...	180	271
Paignton	36	49	...	...	...	...	...	...	...	...	...	...	...
Starcross	34	52	...	77	104	110	105	138	144	156	...	163	255
Tiverton	39	36	...	80	91	111	102	149	153	161	...	...	...
Barnstaple	35	45	83	80	93	120	132	150	150	173	*217*	180	264
Sidcot	25	61	52	85	102	125	132	144	155	175	...	...	...
Clifton	...	...	...	98	...	125	131	...	...	...	...	...	261
Bridgend	...	57	78	87	113	127	135	...	...	167	204	...	...
Little Mill	34	40	80	91	114	122	125	133	146	167	...	170	244
St. Arvans	32	...	76	...	110	...	135	149	162	174	...	...	250
St. Davids	...	44	...	84	...	126	132	157	...	181	...	182	...
Aberystwith	41	50	83	81	95	126	130	133	150	163	183	190	257
B													
Skibbereen	32	...	76	64	...	...	126	148	155	...	...	...	...
Tallow	...	...	43	54	...	124	126	145	...	...	...	...	...
Ferns	36	68	77	79	..	131	134	140	159	191	188	189	259
Bagenalstown	...	...	...	83	...	137	...	151	158	194	...	186	264
Ovoca	14	...	...	78	...	127	138	139	...	...	...	...	...
Geashill	42	45	76	87	*135*	134	141	144	163	174	...	192	...
C													
Bembridge	33	42	...	85	110	116	124	131	...	...	...	...	...
Buckhorn Weston	18	55	78	87	102	125	130	138	150	164	...	183	266
Havant	17	67	76	94	97	125	132	135	151	171	194	186	270
Botley	40	...	79	80	110	128	129	140	151	178	209	190	283
Woolton Hill	47	...	...	92	...	133	138	...	164	175	...	*203*	...
Birdham	38	80	...	88	101	115	125	*150*	150	*149*	...	...	271
Muntham	23	48	60	86	102	128	124	139	154	...	...	177	283
Dover	...	71	...	...	...	119	138	...	164	175	...	...	272
Staplehurst	37	72	76	84	95	...	121	138	150	155	...	180	...
Maidstone	47	50	...	92	104	123	121	139	151	161	189	193	263
Chiddingfold	36	72	73	83	111	122	132	140	154	170	202	194	283
Cranleigh	42	...	...	85	112	128	132	142	157	177	...	187	266
Coneyhurst	37	80	90	88	...	128	*143*	152	161	181	172	195	283
Churt Vicarage	37	79	89	100	107	129	135	145	159	183	186	...	...
Churt	15	78	81	92	112	126	129	143	160	*193*	...	...	...
Bagshot	30	...	90	104	...	126	133	135	156	177	...	191	275
Purley	28	64	...	81	118	122	131	144	151	182	187	197	278
Weston Green	42	66	*106*	93	115	126	129	132	165	167	199	198	257
Marlborough	15	58	71	87	105	126	134	147	154	173	161	187	234
D													
Oxford	...	...	78	81	...	134	...	...	164	...	...	199	268
Beckford	43	...	77	80	105	121	126	139	150	174	195	172	257
Harefield	36	78	99	94	129	128	124	...	153	172	192	...	...
Chesham	39	...	...	89	109	132	135	139	165	198	...	186	259
Watford	39	68	100	97	108	127	125	143	154	165	...	...	271

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1905—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
St. Albans (New Farm)	32	...	81	93	105	126	133	147	154	165	...	...	...
Berkhamsted	40	36	92	99	115	129	*144*	147	153	193	192	184	260
Harpenden	33	58	103	91	109	125	130	157	161	189	203	...	*302*
Ross	35	45	91	80	*87*	118	119	145	147	...	..	...	...
West Malvern	59	45	79	93	108	123	130	152	153	175	191	192	213
Farnborough	22	40	...	88	107	129	135	127	144	195	203	195	283
Northampton	40	69	67	96	114	126	131	151	165	180	183	194	253
Beeston	48	79	...	101	117	*106*	...	158	167	174	159	...	...
Hodsock	41	70	75	94	107	124	135	156	167	179	188	176	267
Macclesfield	56	80	116	116	144	147	150	166	173	186	188	192	274
Belton	46	...	...	...	...	...	...	...	...	...	...	...	...
Altofts	49	45	91	106	126	147	140	155	163	175	179	182	260
Horbury	49	70	...	...	118	...	134	...	...	195	201	203	...
Ripley	35	72	81	112	120	142	145	...	...	...	...	...	...
E													
Broxbourne	41	65	83	95	...	...	...	...	162	...	...	...	267
Hatfield	41	...	...	...	...	122	128	149	154	...	199	...	...
Hertford	15	48	82	82	96	125	120	145	151	177	187	194	264
Sawbridgeworth	34	66	91	87	116	130	136	...	...	...	...	...	273
Hitchin	36	71	85	92	103	122	128	...	153	...	...	...	258
Odsey (Ashwell)	29	59	...	96	...	...	...	...	156	...	...	...	263
Shelford	28	*90*	93	*74*	96	124	129	138	150	180	193	...	...
Bocking	31	67	88	95	110	119	129	158	151	188	...	*210*	268
Lexden	31	60	93	101	115	122	128	139	150	171	187	...	256
Roxton	33	...	78	...	108	124	...	...	...	...	...	...	...
Carleton-Forehoe	40	77	83	102	110	125	137	...	165	181	...	...	...
Tacolneston	34	45	92	100	102	127	138	151	...	165	...	...	...
Brundall	57	71	78	95	106	129	136	148	159	...	...	183	...
Southacre	24	64	79	96	114	128	138	153	166	168	174	188	259
Brunstead	32	70	99	104	108	132	141	151	164	196	194	195	261
Hevingham	...	...	75	...	...	...	142	...	...	...	...	...	...
Clenchwarton	...	78	...	94	118	129	132	...	...	...	...	...	...
Peterborough	39	44	80	82	112	127	126	149	160	198	198	199	257
F													
Palé	51	63	92	102	130	139	147	154	163	194	193	198	287
Betley	37	...	79	103	103	139	140	152	161	181	210	182	262
Manley	58	60	87	100	124	132	135	152	...	...	188	...	...
Birkdale (Southp'rt)	...	71	...	*118*	126	133	137	147	159	185	193	203	277
Lake Side	38	81	81	102	...	*144*	143	159	165	170	189	189	271
Ambleside	36	72	90	99	...	136	...	160	165	...	...	...	...
Cronkbourne	65	55	...	...	123	137	147	159	...	...	...	211	288
Orry's Dale	...	...	...	*120*	..	139	137	164	167	...	196	...	271
G													
Ardgillan	44	62	88	96	...	138	140	152	171	205	...	216	287
Edgeworthstown	...	...	...	101	...	138	145	...	163	...	...	...	...
Westport	56	...	66	100	...	132	138	...	148	...	...	...	269
Chanter Hill	39	41	78	89	104	138	138	154	159	179	...	195	274

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1905—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge-Mustard.	Horse-Chestnut.	Hawthorn.	White Ox-Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Loughbrickland	32	63	*105*	108	...	140	139	160	165	...	...	...	...
Saintfield	72	79	86	105	...	135	140	153	167	201	...	...	...
Antrim	61	...	...	104	104	139	143	154	166	194	...	204	271
Altnafoyle	47	66	...	116	...	133	141	...	165	200	...	...	...
Milford	55	61	77	76	...	*121*	140	158	164	...	...	197	...
H													
Kirkmaiden	...	55	...	113	...	145	147	...	*180*	...	...	197	...
New Galloway	36	77	96	120	...	152	152	...	165	201	191	...	...
Jardington	45	75	82	108	...	142	141	...	159	193	181	...	...
Moniaive	*92*	...	...	121	...	156	155	157	168	197	191	190	*209*
Port Ellen	*84*	...	...	102	...	140	142	...	161	...	190	...	...
I													
Doddington	48	80	90	104	122	131	133	155	171	182	...	...	...
Thirsk	35	60	80	98	115	141	130	153	162	183	185	190	...
Durham	54	74	*106*	...	...	140	143	169	...	...	...	...	...
Corbridge-on-Tyne	36	77	94	114	...	150	148	158	174	...	...	...	...
Blyth	49	46	62	100	...	140	146	...	...	...	...	...	...
J													
Forgandenny	...	...	...	...	...	144	147	...	...	...	...	...	...
Newport	*79*	81	...	111	...	...	...	...	...	...	...	...	...
Kirriemuir	...	73	...	124	...	...	151	168	168	195	188	...	...
Durris	39	47	88	112	...	140	152	156	171	188	184	...	281
Aberdeen	...	80	107	...	...	...	...	...	..	...	203	...	...
Turriff	...	*106*	109	114	...	154	156	166	176	187	190	...	...
Fordyce	44	47	106	120	121	140	144	...	175	175	185	222	279
K													
Invermoidart	...	...	112	...	...	...	149	...	...	...	...	...	285
Roshven	*85*	...	104	...	...	140	141	166	164	199	...	...	*302*
Beauly	51	78	122	124	...	151	151	173	170	189	189	...	285
Dingwall	36	71	94	104	...	138	151	154	157	198	201	...	...
Inverbroom	35	62	108	*88*	...	148	154	154	169	...	...	...	...
Watten	...	77	...	...	...	...	154	184	...	204	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

Observers' Notes.

December 1904.—*Churt Vicarage* (C)—25th. Eleven different kinds of flowers still out in my garden, including rose, wallflower, violet, and pansy. *Bagshot* (C)—Oak leaves all down by the 7th. *Clenchwarton* (E)—Branches broken off the trees by rime between 18th and 27th.

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF 13 PLANTS IN 1905, AND THEIR VARIATIONS FROM THE 15 YEARS' AVERAGE, 1891-1905.

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1905.	Average for 15 Years.	Variation from Average.	1905.	Average for 15 Years.	Variation from Average.	1905.	Average for 15 Years.	Variation from Average.	1905.	Average for 15 Years.	Variation from Average.
Hazel	37	39	− 2	31	32	− 1	32	35	− 3	41	42	− 1
Coltsfoot	54	56	− 2	56	55	+ 1	65	62	+ 3	61	65	− 4
Wood Anemone	80	85	− 5	68	74	− 6	78	84	− 6	88	89	− 1
Blackthorn	86	91	− 5	74	80	− 6	89	97	− 8	95	100	− 5
Garlic Hedge-Mustard	104	107	− 3	...	109	...	107	110	− 3	115	114	+ 1
Horse-Chestnut	122	121	+ 1	131	121	+ 10	125	127	− 2	130	131	− 1
Hawthorn	129	130	− 1	133	128	+ 5	130	132	− 2	133	134	− 1
White Ox-Eye	146	146	0	144	143	+ 1	140	142	− 2	149	148	+ 1
Dog Rose	155	155	0	159	157	+ 2	156	157	− 1	158	160	− 2
Black Knapweed	173	174	− 1	186	181	+ 5	173	171	+ 2	181	178	+ 3
Harebell	197	193	+ 4	188	*186*	+ 2	189	184	+ 5	190	190	0
Greater Bindweed	183	185	− 2	189	190	− 1	189	188	+ 1	189	191	− 2
Ivy	258	263	− 5	261	255	+ 6	279	271	+ 8	260	270	− 10
Mean for the 13 Plants	133	134	− 1	136*	133*	+ 2*	135	135	0	138	139	− 1

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	34	36	− 2	47	44	+ 3	51	52	− 1	40	49	− 9
Coltsfoot	63	61	+ 2	67	66	+ 1	62	70	− 8	69	75	− 6
Wood Anemone	85	87	− 2	86	93	− 7	79	87	− 8	89	100	− 11
Blackthorn	94	98	− 4	101	105	− 4	99	101	− 2	113	112	+ 1
Garlic Hedge-Mustard	108	110	− 2	121	124	− 3	104	*119*	− 15	...	*122*	...
Horse-Chestnut	126	126	0	136	131	+ 5	137	131	+ 6	147	141	+ 6
Hawthorn	133	131	+ 2	141	138	+ 3	140	140	0	147	143	+ 4
White Ox-Eye	148	146	+ 2	156	153	+ 3	155	155	0	157	159	− 2
Dog Rose	157	157	0	163	162	+ 1	163	165	− 2	163	164	− 1
Black Knapweed	180	179	+ 1	182	188	− 6	196	199	− 3	197	199	− 2
Harebell	190	188	+ 2	195	187	+ 8	...	*194*	...	188	189	− 1
Greater Bindweed	192	192	0	197	193	+ 4	203	201	+ 2	193	*198*	− 5
Ivy	263	264	− 1	276	282	− 6	275	276	− 1	...	*277*	...
Mean for the 13 Plants	136	137	− 1	144	144	0	130*	141*	− 2*	137†	130†	− 2†

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	44	49	− 5	41	*55*	− 14	41	*53*	− 12	40	44	− 4
Coltsfoot	67	68	− 1	66	77	− 11	72	75	− 3	64	66	− 2
Wood Anemone	81	94	− 13	102	*101*	+ 1	108	99	+ 9	86	90	− 4
Blackthorn	104	109	− 5	116	*112*	+ 4	114	*110*	+ 4	99	101	− 2
Garlic Hedge-Mustard	118	121	− 3	121	*127*	− 6	...	*125*	...	112	117	− 5
Horse-Chestnut	140	140	0	144	*142*	+ 2	144	*140*	+ 4	135	132	+ 3
Hawthorn	140	142	− 2	150	*146*	+ 4	150	*144*	+ 6	139	137	+ 2
White Ox-Eye	159	160	− 1	163	*160*	+ 3	166	*158*	+ 8	153	152	+ 1
Dog Rose	169	169	0	172	*172*	0	165	*170*	− 5	162	163	− 1
Black Knapweed	182	196	− 14	186	*189*	− 3	197	*187*	+ 10	185	186	− 1
Harebell	185	189	− 4	190	*202*	− 12	195	*200*	− 5	191	191	0
Greater Bindweed	190	197	− 7	222	*203*	+ 19	...	*201*	...	195	194	+ 1
Ivy	...	282	...	280	*282*	− 2	285	*280*	+ 5	271	271	0
Mean for the 13 Plants	132*	136*	− 4*	150	*151*	− 1	149†	*147*†	+ 2†	141	142	− 1

* For 12 Plants. † For 11 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
0 ,, average date (1891-1905).
The dates in *italics* are approximate averages.

JANUARY 1905.—*Tiverton* (A)—11th. Snowdrop in flower. *Geashill* (B)—6th. Snowdrop in bloom. *Cranleigh* (C)—7th. Pipestrelle bat seen. *Berkhamsted* (D)—8th. Winter aconite in flower, 11 days earlier than the average date for the previous 16 years. *Hodsock* (D)—7th. Grass very green. *Ripley* (D)—27th. Great tit heard. *Durris* (J)—7th. Numbers of ripe wortleberries found on the Grampians at the height of 1000 ft.

FEBRUARY.—*Altarnon* (A)—The driest and most favourable winter for many years. 20th. Until now no interruption to farm work through frost. 28th. Cold, rough weather since 21st. *Tiverton* (A)—Garden and wild flowers very early until the 20th, when frosts set in. *Bridgend* (A)—19th. Lark first heard. *Skibbereen* (B)—17th. Song thrushes singing almost every day from the 1st of January until now. *Ovoca* (B)—At the end of the month green leaves were still to be seen on the sweet scented verbena. *Bembridge* (C)—4th. Prunus pissardi in flower. *Coneyhurst* (C)—9th. Common yellow crocus in flower. *St. Albans* (*Worley Road*) (D)—27th. A robin's nest found with five eggs in it. *Hodsock* (D)—28th. Grass very green. *Odsey* (*Ashwell*) (E)—5th. Partridges pairing. *Cronkbourne* (F)—Rhododendrons in flower all the month.

MARCH.—*Altarnon* (A)—31st. The sowing of spring corn very late owing to rain. *Brixham* (A)—21st. Sand-martin first seen. *Starcross* (A)—21st. Wheatear first seen. *Bembridge* (C)—30th. Wryneck first heard. *Botley* (C)—12th. Marsh tit first seen. *Berkhamsted* (D)—19th. An early Rivers' peach in blossom, 5 days earlier than its average date in the previous 19 years. *Harpenden* (D)—2nd. Rooks building. *Ripley* (D)—13th. Skylark first heard. 16th. Pied wagtail first seen. 21st. Grey wagtail first seen. 22nd. Tit-lark first seen. 23rd. Sand-martin first seen. *Roxton* (E)—14th. Frog spawn first seen. *Odsey* (*Ashwell*) (E)—1st. Rooks building. *Brunstead* (E)—3rd. Found an egg of missel thrush. 25th. Frog spawn first seen. *New Galloway* (H)—26th. Wheatear first seen. *Thirsk* (I)—12th. Rooks building. *Fordyce* (J)—16th. Frog spawn first seen.

APRIL.—*Mawnan* (A)—The cold winds at the end of the month injured the fruit and lilac blossom. *Altarnon* (A)—Soil still too wet for sowing spring corn. *Starcross* (A)—Strong South-west winds at end of month cut young leaves of elms and horse-chestnuts and rendered them quite brown, most unusual with a South-west wind. *Botley* (C)—26th. Martins first seen. *Coneyhurst* (C)—14th. Sand-martin first seen. *Churt Vicarage* (C)—5th. Wryneck first heard. *Harefield* (D)—11th. Wryneck first heard. *St. Albans* (*Worley Road*) (D)—3rd. Wryneck first heard. *St. Albans* (*New Farm*) (D)—12th. Garden warbler first heard. *Berkhamsted* (D)—13th. A wild cherry tree in my garden came into flower, 6 days in advance of its average date in the previous 19 years. *Hodsock* (D)—7th. The ground covered with snow. *Altofts* (D)—7th. All young foliage on trees about here blackened by cold winds. *Ripley* (D)—12th. Willow-wren first heard. 22nd. Sandpiper first seen. *Tacolneston* (E)—13th. Wryneck first heard. *Brunstead* (E)—19th. Peach blossom destroyed by frost. *Clenchwarton* (E)—7th. Snow 4 inches deep. Peach blossom destroyed by frost. *Manley* (F)—8th. Blossom on gooseberries and plums injured by frost. *Birkdale* (*Southport*) (F)—25th. Spring insects very late. *Westport* (G)—27th. Sand-martin first seen. *Altnafoyle* (G)—29th. Fieldfares last seen. *Corbridge-on-Tyne* (I)—25th. House-martin and sand-martin first seen. *Durris* (J)—22nd. Sand-martin first seen.

MAY.—*Mawnan* (A)—22nd. Frost blackened new potatoes. Rain much wanted for farm seeds. 29th. First hay cut *Altarnon* (A)—The cold winds and frosts of the month cut down kidney beans and potatoes, and destroyed much of the fruit blossom 20th. May-fly first seen *St. Arvans* (A)—13th. Tree pipit and blackcap heard. 28th. Rain much wanted both on farm and in

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1905.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Mawnan	15	83	122	...	...	...	53	137	78	...	*105*
Altarnon	7	102	115	...	135	283	45	79	83	124	151
Brixham	10	84	122	...	...	283	82	...	112	138	...
Paignton	12	...	...	...	...	...	...	...	...	...	...
Starcross	4	93	104	...	146	311	31	127	95	126	170
Tiverton	...	102	...	...	...	...	48	...	...	...	...
Sidcot	...	101	102	114	...	...	...	...	...	...	...
Clifton	22	...	..	...	...	...	...	...	...	...	...
Penarth	...	...	...	...	...	...	85	...	98	140	177
Bridgend	8	92	...	...	...	...	76	...	...	...	...
Little Mill	29	94	102	*129*	128	286	34	76	95	105	130
St. Arvans	30	111	114	...	...	...	...	...	83	147	...
St. Davids	...	89	111	...	...	298	83	...	118	132	176
Aberystwith	8	102	122	...	132	*368*	45	123	120	132	163
B											
Skibbereen	1	...	121	...	...	320	38	125	106	118	...
Tallow	...	105	120	...	...	...	*96*	138	125	131	137
Ferns	3	97	119	...	...	287	63	137	90	*91*	125
Bagenalstown	4	105	...	...	...	*261*	5	...	...	124	...
Ovoca	7	100	113	..	123	...	44	100	81	131	...
Geashill	...	111	121	...	...	...	38	...	124	...	175
C											
Bembridge	2	92	100	114	...	308	44	...	...	137	169
Buckhorn Weston	2	93	101	...	144	298	...	...	111	124	...
Havant	9	91	102	102	121	342	58	60	102	137	174
Botley	2	91	100	112	140	293	7	89	124	127	176
Woolton Hill	...	108	108	112	...	291	41	100	107	107	...
Birdham	10	98	105	100	...	334	32	95	105	127	181
Muntham	10	100	99	103	144	300	...	79	128	136	...
Dover	...	105	...	...	...	314	...	...	...	...	...
Staplehurst	32	88	101	...	...	...	32	40	124	*180*	...
Maidstone	17	*123*	109	109	128	290	76	130	102	139	...
Chiddingfold	7	102	95	104	132	283	24	130	121	121	153
Cranleigh	...	106	99	104	...	295	76	...	124	132	...
Coneyhurst	*41*	102	100	101	...	276	40	...	120	...	...
Churt Vicarage	8	105	103	104	141	289	41	126	105	128	...
Churt	...	103	106	105	126	308	21	73	119	132	157
Bagshot	7	101	99	...	138	283	42	90	125	138	164
Purley	1	118	104	105	138	301	64	85	127	...	176
Weston Green	5	*126*	103	*122*	*167*	279	45	119	105	...	...
Marlborough	6	100	108		...	...	...	...	98	135	169
D											
Oxford	...	...	108	...	...	...	...	...	...	...	...
Beckford	36	106	105	105	148	290	25	105	105	125	...
Harefield	...	106	102	103	...	290	73	...	...	146	...
Chesham	31	97	101	...	...	274	43	127	124	140	..
Watford	...	110	110	103	...	289	33	115	121	...	...
St. Albans (Worley Road)	9	96	101	103	...	293	...	...	...	...	...
St. Albans (New Farm)	5	101	102	102	146	291	...	...	105	129	176

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1905—*continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
Berkhamsted	8	87	116	111	147	287	73	80	96	137	164
Harpenden	...	104	99	119	...	...	...	81	126	139	*125*
Ross	5	95	108	107	144	...	45	...	106	123	...
West Malvern	...	118	105	126	145	282	77	132	123	121	168
Farnborough	1	98	105	127	136	297	35	121	*77*	127	157
Beeston	4	107	113	...	144	281	77	124	126	...	...
Hodsock	30	101	114	129	142	304	30	128	122	145	...
Macclesfield	22	124	125	...	...	276	105	126	146	...	...
Belton	32	...	...	...	...	...	35	...	...	...	...
Altofts	...	112	...	...	...	300	...	...	105	155	182
Ripley	9	89	102	...	146	*264*	78	126	127	138	...
E											
Broxbourne	4	106	105	107	153	321	29	51	...	...	...
Hatfield	9	102	101	113	*166*	...	...	45	102	132	...
Sawbridgeworth	9	101	101	113	142	302	29	78	119	130	...
Hitchin	9	102	102	106	...	...	...	...	...	152	...
Odsey (Ashwell)	...	103	103	106	145	291	...	...	...	...	...
Shelford	32	92	110	105	138	...	49	89	107	130	172
Bocking	...	*125*	117	112	...	...	...	...	...	...	...
Lexden	7	102	118	103	145	309	67	75	105	122	174
Roxton	...	103	113	...	...	...	29	...	...	...	...
Carleton-Forehoe	10	103	...	*123*	131	294	28	105	110	138	146
Tacolneston	28	108	112	...	...	296	29	...	...	130	...
Brundall	...	...	105	...	...	...	*114*	...	...	...	...
Southacre	13	110	120	104	132	294	46	113	121	145	170
Brunstead	30	105	104	...	135	303	47	69	82	147	183
Hevingham	37	114	114	...	...	...	...	...	...	...	...
Clenchwarton	29	103	112	...	...	311	47	32	105	137	...
Peterborough	5	108	108	111	...	...	34	130	...	143	...
F											
Palé	7	101	113	...	133	*268*	62	128	135	154	188
Betley	34	102	102	...	137	281	...	100	92	123	*201*
Manley	15	110	117	...	...	...	78	119	...	155	183
Birkdale (Southport)	25	131	*133*	...	133	285	53	100	131	149	171
Preston	32	103	117	...	...	292	48	...	105	...	...
Lake Side	*45*	111	122	...	153	...	38	133	106	137	193
Ambleside	28	119	119	...	134	...	38	131	...	...	...
Cronkbourne	24	98	*134*	...	...	273	7	119	124	126	130
Orry's Dale	4	101	118	...	...	...	4	100	114	...	...
G											
Ardgillan	3	120	119	...	156	277	...	86	111	127	164
Edgeworthstown	2	102	119	...	130	...	95	...	122	124	...
Westport	2	104	131	...	...	262	...	48	...	...	...
Chanter Hill	8	91	119	...	...	266	78	115	115	121	137
Loughbrickland	30	107	120	...	...	265	...	...	129	140	...
Saintfield	6	110	121	...	143	277	...	...	128	133	...
Antrim	19	103	124	...	148	275	81	103	103	112	...
Altnafoyle	23	126	135	...	...	...	103	126	133	127	177
Milford	...	119	122	...	...	...	63	139	122	132	...

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1905—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
H											
Kirkmaiden	19	103	118	...	...	...	79	...	124	...	...
New Galloway	34	115	116	...	...	...	35	134	136	...	...
Jardington	30	117	120	...	134	273	105	127	123	...	183
Moniaive	...	103	120	...	...	272	...	...	...	...	...
Port Ellen	27	112	117	...	...	...	25	...	...	...	...
I											
Thirsk	28	102	118	...	...	274	38	127	*78*	137	...
Durham	38	107	*132*	...	140	269	*128*	130	...	...	...
Corbridge-on-Tyne	38	112	120	...	...	270	...	...	...	...	...
Blyth	38	114	119	...	...	281	67	...	131	...	...
J											
Forgandenny	...	*140*	126	...	148	...	...	...	...	...	...
Newport	23	...	...	...	...	...	...	...	...	...	...
Kirriemuir	...	113	...	...	...	283	63	...	...	...	...
Durris	22	120	122	...	...	261	47	87	148	...	199
Aberdeen	21	118	...	...	...	255	...	138	...	...	...
Turriff	*68*	122	*164*	...	134	...	73	137	152	...	*127*
Fordyce	...	121	124	...	...	278	79	127	127	...	...
K											
Invermoidart	39	...	123	...	...	...	...	122	...	...	...
Roshven	...	...	...	...	...	...	...	141	...	...	...
Beauly	*76*	136	135	...	161	263	69	138	136	...	...
Dingwall	21	117	130	...	160	...	63	134	...	...	...
Inverbroom	38	...	123	...	...	...	70	134	135	...	...
Watten	...	...	*161*	...	...	...	78	...	143	...	175
Mean Dates for the British Isles in 1905	17 Jan. 17	105 Apl. 15	112 Apl. 22	109 Apl. 19	140 May 20	289 Oct. 16	52 Feb. 21	108 Apl. 18	115 Apl. 25	133 May 13	167 June 16
Mean Dates for 1891-1905	Jan. 24	Apl. 17	Apl. 22	Apl. 21	May 15	Oct. 12	Feb. 25	Apl. 12	Apl. 19	May 10	June 11

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

garden. *Botley* (C)—21st. Potatoes blackened by frost. Oak leaves also injured on the windward side. Owing to drought the lawns are almost as brown as they often are in August. *Woolton Hill* (C)—22nd. Beans and potatoes cut down by frost. *Chiddingfold* (C)—Hay very short. *Churt Vicarage* (C)—23rd. Potatoes and young shoots on common laurel blackened by frost. Young foliage of oaks destroyed. 24th. May-fly first seen. 25th. First swarm of bees. *Churt* (C)—21st. Bush fruits and shrubs severely cut by frost. *Bagshot* (C)—

TABLE VI.—Estimated Yield of Farm Crops in 1905.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
	%	%	%	%	%	%	%	%	%	%	%
Wheat	+ 7	+ 7	+10	+ 3	+ 5	+ 9	+ 9	+11	+ 8	+13	+ 6
Barley	+ 4	+ 4	+ 7	+ 3	- 3	+ 4	+ 2	+ 3	+ 8	+10	+ 4
Oats	+ 3	- 4	- 3	+ 2	- 3	-12	+ 4	- 3	+ 5	+ 4	Av.
Corn Harvest began, average Date, day of Year	216	212	214	211	219	218	226	232	...	227	219
Beans	+ 2	+ 8	+20	+12	+ 5	+ 6	+13	0	+12	+ 8	+14
Peas	+ 8	- 2	+ 4	+ 1	+ 3	0	+15	- 1	- 1	+ 1	- 2
Potatoes	- 2	- 6	+ 9	- 3	+10	+10	+14	+10	- 9	+26	+17
Turnips	- 3	+16	+12	+ 7	-15	+ 4	+ 9	+ 3	+ 9	+ 9	+ 7
Mangolds	+11	+ 9	+12	+11	0	+ 7	+ 2	- 1	+36	+ 7	+ 9
Hay (Permanent Pastures)	+ 2	+ 6	- 9	- 2	- 6	-20	- 3	+ 2	+18	+ 1	- 3
Hay (Clover, etc.)	+ 1	+ 6	+ 5	+ 2	- 1	- 5	- 2	+ 1	+ 2	+ 3	+ 1

Symbols :— + = Over. - = Under. 0 = Average.

The variations from the average in the above-mentioned crops have been obtained from the *Agricultural Returns*, 1905 (*Produce of Crops*), issued by the Board of Agriculture, while the average dates of the Harvest have been derived from returns which appeared in the *Agricultural Gazette*, July 24 to August 21, 1905.

TABLE VII.—Estimated Yield of Fruit Crops in 1905.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H, J, and K W. E. and N.	B and G S. and N.	
Apples	-	-	-	-	-	-	-	-	-
Pears	-	-	-	-	-	-	-	-	-
Plums	-	-	-	-	-	-	-	-	-
Raspberries	+	+	+	0	+	0	+	+	+
Currants	+	+	+	0	+	0	+	+	+
Gooseberries	+	+	+	0	+	0	+	+	+
Strawberries	+	-	0	0	+	0	+	+	+

Symbols :— + = Over. - = Under. 0 = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, July 29, 1905.

TABLE VIII.—Variations from the Average in Mean Temperature, Rainfall, and Sunshine, 1904-5.

Winter 1904-5.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	+1·2	+1·5	+1·7	−0·5	+0·2	−1·8	+0·5	−1·0	−0·5	0·0	+1·2
January	−0·7	+2·0	−0·2	−0·7	−0·2	+0·2	+2·2	+1·7	+0·7	+1·7	+2·2
February	+1·7	+1·5	+2·5	+2·2	+2·2	+1·7	+1·5	+1·7	+2·5	+2·2	+0·7
Winter	+0·7	+1·7	+1·3	+0·3	+0·7	0·0	+1·4	+0·8	+0·9	+1·3	+1·4

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	−0·3	−1·8	+0·4	−0·5	+0·1	−0·2	−0·9	−1·4	−0·4	−0·2	+0·4
January	−2·0	−0·9	−1·2	−1·2	−0·8	−1·1	−0·4	−1·6	−1·2	−1·6	+0·8
February	−2·0	−1·9	−1·7	−1·5	−0·9	−1·1	−0·6	−0·9	−1·0	−1·0	+2·6
Winter	−4·3	−4·6	−2·5	−3·2	−1·6	−2·4	−1·9	−3·9	−2·6	−2·8	+3·8

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	− 6	− 3	− 6	− 5	− 4	+10	+ 1	+ 4	+ 7	− 3	− 4
January	+13	−14	+21	+16	+23	− 1	−16	− 3	− 3	− 1	− 2
February	− 1	+ 5	+ 9	+ 4	+15	+16	+ 8	+16	+ 2	+ 3	− 2
Winter	+ 6	−12	+24	+15	+34	+25	− 7	+17	+ 6	− 1	− 8

Spring 1905.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	+1·6	+0·2	+2·2	+2·2	+2·4	+1·6	+0·2	+1·4	+2·2	+1·4	+2·0
April	0·0	−1·0	−1·0	−1·2	−0·7	−1·7	−1·5	−2·2	−1·2	−2·5	−3·0
May	−0·4	+1·2	+0·4	+0·2	+1·0	0·0	+0·4	+1·0	+1·0	+1·0	0·0
Spring	+0·4	+0·1	+0·5	+0·4	+0·9	0·0	−0·3	+0·1	+0·7	0·0	−0·3

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	+3·1	+2·8	+2·5	+1·3	+0·3	+1·9	+2·4	+2·4	−0·1	+1·7	+1·9
April	+0·5	+0·4	−0·1	+0·2	+0·2	+0·5	−0·1	0·0	+0·2	+0·1	−0·1
May	−1·7	−1·2	−1·1	−1·3	−0·9	−1·3	−0·8	−0·2	−1·3	−0·7	+0·1
Spring	+1·9	+2·0	+1·3	+0·2	−0·4	+1·1	+1·5	+2·2	−1·2	+1·1	+1·9

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	− 1	+19	+ 3	+ 7	+11	+37	+43	+16	+ 1	−17	−29
April	−60	−61	−55	−38	−46	−12	−15	−16	−25	−24	− 9
May	+32	+26	+53	+18	+28	+29	+44	− 4	−29	−12	− 8
Spring	−29	−16	+ 1	−13	− 7	+54	+72	− 4	−53	−53	−46

+ indicates above the average, − below it.

TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1905.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June . .	+1·0	+2·0	+0·7	+1·2	+1·7	+1·0	+2·0	+2·2	+0·5	+0·5	+2·2
July . .	+2·5	+3·0	+3·2	+3·5	+4·7	+2·2	+1·7	+2·2	+4·0	+2·2	+1·5
August . .	−1·6	−1·0	−0·6	−1·0	+0·4	−1·0	−1·2	−0·6	+0·2	−0·8	0·0
Summer . .	+0·6	+1·3	+1·1	+1·2	+2·3	+0·7	+0·8	+1·3	+1·6	+0·6	+1·2
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June . .	+1·1	−0·6	+2·4	+0·6	+1·8	+0·3	−0·5	−1·3	−0·3	−1·0	−1·5
July . .	−1·7	−1·2	−1·5	−1·4	−1·6	−0·7	−0·9	−0·4	−1·2	−0·5	−0·1
August . .	+1·0	+1·3	+0·2	+0·8	−0·1	+0·4	+1·2	+1·1	+0·2	0·0	+1·2
Summer . .	+0·4	−0·5	+1·1	0·0	+0·1	0·0	−0·2	−0·6	−1·3	−1·5	−0·4
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June . .	−41	+28	−28	−16	−3	+52	+79	+68	+57	+47	+57
July . .	−6	−20	+32	+41	+41	+42	+1	+2	+52	+24	+7
August . .	−21	−15	−18	−10	−10	−2	−6	−4	+7	−9	−4
Summer . .	−68	−7	−14	+15	+28	+92	+74	+66	+116	+62	+60

AUTUMN 1905.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September .	−1·7	−1·2	−1·7	−1·0	0·0	−2·0	−1·0	−0·5	−0·2	−0·2	0·0
October . .	−4·0	−3·2	−5·0	−3·7	−4·7	−3·7	−2·0	−3·0	−3·5	−2·2	−2·7
November .	−2·6	−3·0	−1·8	−1·8	−1·2	−2·0	−1·4	−1·2	−1·6	−1·4	−0·4
Autumn . .	−2·8	−2·4	−2·8	−2·2	−2·0	−2·6	−1·5	−1·6	−1·8	−1·3	−1·0
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September .	−1·5	−1·3	−0·6	−1·1	−0·5	−1·3	−1·2	−1·3	−0·5	−1·0	−0·3
October . .	−2·7	−2·6	−2·2	−1·6	−0·6	−1·0	−1·2	−0·9	+0·1	−0·5	−0·1
November .	+1·1	−0·3	+1·9	+0·7	−0·3	+0·7	+0·7	−0·8	+1·2	+2·4	−0·2
Autumn . .	−3·1	−4·2	−0·9	−2·0	−1·4	−1·6	−1·7	−3·0	+0·8	+0·9	−0·6
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September .	0	−13	−26	−4	−3	+9	+11	+24	+8	+11	+23
October . .	+17	+6	+3	+4	−8	+17	+2	+25	+15	+5	−14
November .	+29	+1	+5	+4	−3	+20	−4	0	+4	0	+1
Autumn . .	+46	−6	−18	+4	−14	+46	+9	+49	+27	+16	+10

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

TABLE IX.—Supplementary Observations in 1905.

PLANTS.

Winter Aconite.

Station.	District.	Date.
Bembridge	C	Jan. 4.
Churt Vicarage	C	,, 25.
Berkhamsted	D	,, 8.
Hodsock	D	Feb. 4.
Ripley	D	Jan. 6.
Clenchwarton	E	,, 24.
New Galloway	H	,, 12.

BIRDS.

Chiff-Chaff (first heard).

Station.	District.	Date.
Starcross	A	March 21.
Ovoca	B	,, 22.
St. Albans (New Farm)	D	April 5.
Ross	D	March 29.
Ripley	D	,, 23.
Edgeworthstown	G	,, 22.
Loughbrickland	G	April 4.
Altnafoyle	G	May 6.

Corncrake (first heard).

Station.	District.	Date.
Ovoca	B	April 17.
St. Albans (Worley Road)	D	,, 24.
Hodsock	D	May 2.

Corncrake (first heard)—*continued.*

Station.	District.	Date.
Macclesfield	D	May 13.
Ripley	D	,, 5.
Westport	G	April 26.
Loughbrickland	G	,, 27.
Altnafoyle	G	May 5.
Jardington	H	,, 7.
Moniaive	H	,, 5.
Thirsk	I	,, 14.
Corbridge-on-Tyne	I	April 30.
Fordyce	J	May 8.
Watten	K	,, 27.

Swift (first seen).

Station.	District.	Date.
Botley	C	May 12.
Cranleigh	C	,, 9.
Churt Vicarage	C	,, 11.
Harefield	D	,, 13.
St. Albans (Worley Road)	D	,, 11.
Macclesfield	D	,, 11.
Ripley	D	,, 2.
Odsey	E	,, 18.
Lake Side	F	,, 5.
Westport	G	,, 10.
Altnafoyle	G	,, 12.
New Galloway	H	,, 11.
Corbridge-on-Tyne	I	,, 14.
Fordyce	J	,, 17.

23rd. Vegetable marrows and scarlet runners blackened by frost. *Purley* (C).—23rd. Frost slightly injured dahlias in a very sheltered spot. *Weston Green* (C)—23rd. Considerable damage done to fruit blossom, potatoes, etc. *Marlborough* (C)—Much of the foliage of the beech and ash, and also most of the apple blossom, were destroyed by frost. *Berkhamsted* (D)—5th. A Blenheim orange-apple came into blossom 1 day earlier than its average date in the previous 19 years. *Harpenden* (D)—23rd. Potatoes cut down by frost. *Beeston* (D)—Abundant blossom on hawthorn. Swallows seem few in number this year. 23rd. Much damage done to strawberry blossom by frost. *Macclesfield* (D)—23rd. Early potatoes killed by frost. *Hertford* (E)—Never remember the nightingale so little in song. *Odsey* (*Ashwell*) (E)—1st. Turtle dove first seen. *Bocking* (E)—Abundant blossom on pears, also on hawthorn and other wild shrubs. *Lexden* (E)—Wasps unusually numerous. *Southacre* (E)—23rd. Potatoes cut down by frost, and foliage of ash-trees blackened. *Palé* (F)—23rd. Potatoes and foliage of trees injured by frost. *Betley* (F)—Wireworm very destructive owing to dry weather. Potatoes injured by frost. *Birkdale* (*Southport*) (F)—15th. Sandhill beetles about three weeks late. *Lake Side* (F)—A great many queen wasps. *Cronkbourne* (F)—Queen wasps very numerous. 23rd. Tender plants blackened by frost. *Westport* (G)—4th. Martin first seen. *Altnafoyle* (G)—6th. Willow-wren first heard. *Jardington* (H)—Hawthorn

and apple blossom scanty, pear blossom abundant. *Doddington* (I)—23rd. Potatoes and young oak leaves blackened by frost. *Thirsk* (I)—23rd. Potatoes cut down by frost.

JUNE.—*Mawnan* (A)—20th. All wild flowers exceptionally abundant and good. *Altarnon* (A)—The showers in the middle of the month improved the grass and corn. *Tiverton* (A)—2nd. The long drought is retarding the flowering of wild and other plants. *Bagenalstown* (B)—The blossom on hawthorns and laburnums unusually abundant. *Geashill* (B)—An unusual number of white butterflies. *Bembridge* (C)—11th. Owing to rain coming after a very warm and dry time, some pear and other fruit trees flowered a second time. *Woolton Hill* (C)—Abundant blossom on hawthorn. *Oxford* (D)—13th. Many elms, planes, and sycamores with less than their usual quantity of foliage. *St. Albans (Worley Road)* (D)—20th. Cuckoo last heard. *Odsey (Ashwell)* (E)—Swallows are scarce here this year, nearly all their usual nesting-places are deserted. 4th. Wheatear first seen. *Clenchwarton* (E)—Hawthorn blossom unusually abundant. *Betley* (F)—28th. Cuckoo last heard. *Birkkale (Southport)* (F)—Cabbage and other butterflies very numerous. Blossom abundant on hawthorn and laburnum. 7th. Haymaking began. *Lake Side* (F)—10th. Acres of trees stripped of their leaves by caterpillars. The woodmen said they could hardly peel the oak bark as there was no sap owing to dry weather. *Cronkbourne* (F)—9th. Hay cutting began. *Antrim* (G)—White butterflies have been very numerous. *New Galloway* (H)—26th. Cuckoo last heard. *Moniaive* (H)—15th. In consequence of a month's drought the black-headed gulls experienced great difficulty in procuring food; some perished, while numbers of famished birds were seen daily in and about the villages. *Thirsk* (I)—17th. Hay first cut.

JULY.—*Mawnan* (A)—24th. Harvest began. *St. Arvans* (A)—25th. First corn cut. *Woolton Hill* (C)—21st. Hay harvest finished. 25th. Corn harvest began. *Coneyhurst* (C)—2nd. Cuckoo last heard. *Bagshot* (C)—25th. Harvest began. *Beckford* (D)—26th. Harvest began. *Harefield* (D)—20th. Oats first cut. *Beeston* (D)—22nd. Pastures bare and brown and ponds dry. 24th. Harvest began. *Odsey (Ashwell)* (E)—17th. Winter oats cut. *Bocking* (E)—25th. Pastures beginning to look very brown. *Tacolneston* (E)—House-martins unusually numerous this year. *Southacre* (E)—5th. Green sandpiper first seen, very early. *Brunstead* (E)—Swedes much injured by larvæ of the diamond-backed moth, which was very abundant this year. *Clenchwarton* (E)—26th. Harvest began. *Palé* (F)—Abundant blossom on the elder and honeysuckle. *Betley* (F)—15th. First corn cut. *Birkdale (Southport)* (F)—2nd. Cuckoo last heard. *Cronkbourne* (F)—31st. Harvest began. *Port Ellen* (H)—The dry weather favoured peat cutting.

AUGUST.—*Mawnan* (A)—1st. Harvest in full swing and threshing machine in use in a field at the same time. 17th. In exposed places the leaves of trees were browned and shrivelled by the gale which occurred earlier in the month. *Altarnon* (A)—10th. Refreshing rains improved farm crops. 31st. Gorse and heather never finer on the moors. *St. Arvans* (A)—Not so many wasps as usual. 17th. Last corn carried. *Bagenalstown* (B)—Quantities of mushrooms this year, none at all last year. *Ovoca* (B)—A good year for mushrooms, very few wasps. *Woolton Hill* (C)—Wasps very numerous. *Churt Vicarage* (C)—Very few wasps. *Bagshot* (C)—Wasps numerous. *Harefield* (D)—10th. Blackberries ripe. *Hodsock* (D)—19th. Much damage done in the garden by the gale. *Ripley* (D)—17th. Swift last seen. *Odsey* (Ashwell) (E)—10th. Finished carting wheat. 25th. Finished carting barley. *Southacre* (E)—24th. Harvest finished. 25th. Swift last seen. *Clenchwarton* (E)—26th. Harvest ended. *Palé* (F)—Scarcely any corn harvested owing to frequent and heavy rains. *Birkdale (Southport)* (F)—Wasps numerous. Great profusion of wild flower blossoms. 5th. Harvest began. *Lake Side* (F)—19th. Foliage of trees

injured by gale. *Ardgillan* (G)—11th. Swallows first seen to congregate and move south. *Antrim* (G)—Few wasps have been seen. 10th. Swift last seen. *Altnafoyle* (G)—Wasps unusually numerous. *Jardington* (H)—9th. Harvest began. *Moniaive* (H)—5th. Harvest began, an unusually early date. *Durris* (J)—7th. Harvest began. 14th. Wasps unusually numerous. *Fordyce* (J)—Wasps numerous. 14th. Swift last seen.

SEPTEMBER.—*Altarnon* (A)—14th. Garden and wild flowers unusually fine. 25th. Harvest finished. *Botley* (C)—More herons than usual. *Churt Vicarage* (C)—15th. Vegetable marrows destroyed by frost in lower part of parish. *Bagshot* (C)—Very few mushrooms. *St. Albans* (*New Farm*) (D)—Blackberries scarce and much blighted. *Odsey* (*Ashwell*) (E)—1st. Harvest finished. *Bocking* (E)—A great abundance of most sorts of wild fruits, such as beech, maple, etc., but not many acorns. *Southacre* (E)—Haws and blackberries abundant. *Brunstead* (E)—Water very low in ponds and ditches. *Clenchwarton* (E)—1st. Very few holly berries and very few wasps. *Birkdale* (*Southport*) (F)—Wasps more plentiful than in the three preceding years. *Antrim* (G)—Mushrooms plentiful. *Thirsk* (I)—12th. Harvest completed—the earliest date since 1868. *Durris* (J)—Blackberries very abundant.

OCTOBER.—*Mawnan* (A)—17th. A very slight frost. *Altarnon* (A)—23rd. Dahlias killed by frost and mangolds injured. *Tiverton* (A)—The frosts after the middle of the month cleared the gardens and hedges of all flowers earlier than usual. *St. Arvans* (A)—Begonias blackened by frost. *Aberystwith* (A)—16th to 20th. Sharp frosts cut down tender garden plants three weeks before the usual time. *Bembridge* (C)—17th. Dahlias killed by frost. *Woolton Hill* (C)—18th. All tender plants cut down by frost. *Chiddingfold* (C)—10th. Severe frost. *Coneyhurst* (C)—7th. Sand-martin last seen. *Churt Vicarage* (C)—14th. Dahlias killed by frost; this frost quite ruined the usual show of autumn flowers. *Churt* (C)—The frost more severe here than for many years past in October. *Bagshot* (C)—Scarcely any acorns, but a heavy crop of beach mast. 17th. Dahlias killed. *Weston Green* (C)—22nd. Dahlias and all bedding plants killed by frost. *Beckford* (D)—17th. Dahlias killed. *Harefield* (D)—15th. Martin last seen. *St. Albans* (*Worley Road*) (D)—17th. House-martin last seen. *St. Albans* (*New Farm*) (D)—17th. Nasturtiums killed by frost. *Berkhamsted* (D)—17th. Dahlias killed by frost, 3 weeks earlier than the average date of their destruction in the previous 20 years. *Hodsock* (D)—17th. Dahlias, begonias, and cannas completely blackened. Have hardly ever before seen them so entirely destroyed in one night. 21st. Fieldfares arrived. *Lexden* (E)—20th. The swallows and martins are staying very late this year; the latter still have young ones in their nests. *Brunstead* (E)—Very few acorns. 23rd. Fieldfares first seen. *Palé* (F)—Dahlias killed by frost. *Birkdale* (*Southport*) (F)—The leaves remained on the trees longer than usual. Holly berries numerous. *Lake Side* (F)—14th. Frost killed vegetable marrows. *Cronkbourne* (F)—15th. Dahlias killed by frost. *Antrim* (G)—15th. Dahlias killed by frost. *Durris* (J)—10th. Harvest completed. 30th. Fieldfares first seen.

NOVEMBER.—*Mawnan* (A)—19th. Dahlias killed. *Brixham* (A)—3rd. A number of house-martins seen. *Churt Vicarage* (C)—23rd. The leaves have fallen very rapidly this year. *Bagshot* (C)—12th. All leaves down except those on the oak. 26th. The heavy winds brought down the remaining oak leaves. *Chesham* (D)—Martins were seen at the beginning of the month. *St. Albans* (*New Farm*) (D)—Flocks of golden plover on fields of new sown corn. *Clenchwarton* (E)—7th. Fieldfares first seen.

DISCUSSION.

Mr. H. SOUTHALL said he was always deeply interested in the phenological report, and had come especially from Ross to hear it. He thought Mr. Mawley took great pains to ascertain the principal facts of the year, and then cleverly placed them before the meeting in a manner most readily to be understood. It was noticeable that Mr. Mawley placed the Hawthorn and Blackthorn in different tables. He thought the two plants were the best of the series. He did not think Mr. Mawley had exaggerated the effect of the severe frosts of November 1904, and the terrible destruction that they wrought. He himself did not remember so severe a frost at such a time of year. October 1905, again, was also remarkable for the long-continued succession of frosty nights.

Mr. F. C. BAYARD said that he gathered from Mr. Mawley's statement that the root crops were rather short of the average, but the Board of Agriculture in their report stated that they were in excess of the average. He preferred to take Mr. Mawley's figures, but he would like to ask if any explanation of the discrepancy could be given. One other point he would like to refer to was the destruction of bud and blossom by wild birds. During the last few years the gardens in and around Wallington had suffered greatly from the depredations of such birds as thrushes, blackbirds, finches, and also sparrows, and he would like to ask if Mr. Mawley had received information from other parts of the country on the matter. He thought that the Wild Birds Preservation Act in protecting the birds from molestation was perhaps doing unintentional mischief in allowing them to increase in such numbers.

Mr. J. E. CLARK said that he had heard several accounts of the depredations of wild birds, and Mr. J. Cheal, of the Lowfield nurseries near Crawley, had told him that his lilac bushes of special kinds had been almost denuded of blossom buds by bullfinches and sparrows. Bullfinches were much more numerous of recent years, probably owing to the succession of mild winters. The great increase of starlings was also noticeable, and at their roosting-places they were to be found in great numbers. Whereas ten years ago their flocks were comparatively small, now they were as large as ever. He had noticed that, besides the apple crop being poor, the fruit was keeping very badly. This was especially marked in Somerset, the county of the apple. In spite of the severe frost of last October, at Christmas time there were found in the Croydon district 33 species of wild plants in bloom, as compared with only 7 of the previous year, and of garden varieties 15 were seen as against 7 of Christmas 1904. Of course the flowers were nothing to look at, but they could be said to be in bloom.

Mr. J. HOPKINSON said that he thought the date of the thunderstorm which destroyed the oak-tree must have been Sunday, July 9. On that day two trees near Watford were struck by lightning, one of which (a larch) was stripped of a narrow piece of bark about an inch wide all the way down the trunk, looking as though it had been cut out by hand. His own experience with regard to the birds was that the frugivorous species had largely increased in number in recent years, and each year for the last three years at least they had done greater damage, especially to the cherry-trees, from which, in his own garden, they stripped off nearly all the fruit.

Mr. C. HARDING spoke of the increasing value of the table of the 15 years' means, and thought it was the most important part of the report. He had noticed that evening a remarkable coincidence of the similarity of means of the years 1898 and 1905, and he wondered if Mr. Mawley could give any information as to any agreement of the weather conditions of the two years. Mr

Mawley had now worked up these observations for so long a period that he hoped one day he would be able to forecast our seasons for us, and be able to say if we were likely to have good crops or bad. In his own garden, about 4 miles from Westminster, he (Mr. Harding) had a number of fruit trees, and he had frequently noticed that these were more successful with their fruit than others with large gardens. No doubt this was owing to their sheltered position from frosts and keen winds. They were specially favoured with apples this last year, but the fruit did not keep any length of time, owing to the presence of an undue amount of maggots, although the trees had been kept well cleaned. On the other hand, pears were of poor quality.

Mr. F. DRUCE thought that the report proved the connection of Meteorology with the affairs of everyday life. In a single night one farmer alone had lost the sum of £400 by a frost. He thought the people of this country should wake up and get some means of foretelling such a destructive frost. Was it too much to ask that the country should demand such information? He had noticed that the small fruit crop, grown near the ground, was fairly good while tree fruit was poor. The hop crop also, which was neither near the ground nor on a tree, was also good, and he wondered if there was any connection between the distance of the crop from the ground and its success.

Mr. D. W. HORNER, referring to the damage caused in Sussex by the autumn frosts, said that the outdoor chrysanthemums at Worthing were mostly destroyed. As to the May frosts, French growers guarded against them by lighting large fires and thus creating a great quantity of smoke when it was thought likely that they would occur. English farmers, however, were much too conservative to adopt such measures.

Mr. N. FFARINGTON said that previous speakers had referred to the enormous damage to blossom and bud caused by birds, but he himself had noticed some destruction by caterpillars.

Mr. E. MAWLEY, in reply, said, in regard to the interesting remark made by Mr. Southall as to the time which usually elapsed between the flowering of the blackthorn and hawthorn in his neighbourhood, that such comparisons required to be made with great care, on account of the very different dates at which the individual hawthorn bushes came into blossom—this being no doubt due to the fact that so many of them were merely chance seedlings. From an agricultural point of view October would no doubt be the best month with which to begin the Phenological year, but all things considered he thought December preferable, as during that month vegetation had about reached its lowest level. As to the effects of the keen frosts in November 1904, reference to these would be found in the previous report. There was certainly, as pointed out by Mr. Bayard, an apparent discrepancy between the account given in the present report as to the progress made during the year by swedes and turnips and the official return of their estimated yield, which could only be reconciled by the surprising improvement made by these crops during the autumn months. The increase in recent years in the number of bullfinches and other destructive birds might, as Mr. Clark had pointed out, be due in some measure to the mildness of the last few winters. The indifferent way in which apples had kept this winter might be due to the continued cold of the autumn not allowing the fruit to become sufficiently ripened. As Mr. Harding had pointed out, the year nearest to an average year from a phenological point of view after 1905 was that of 1898, as was shown by Table I. Mr. Mawley said he could never hope from his tables to forecast coming weather; but after writing so many of these reports he thought that he could very fairly describe the progress of the various farm crops during any year, if he only had before him the atmospheric conditions which had prevailed during the course of it. It certainly appeared sad that our fruit crops were so greatly at the mercy of late spring frosts. No doubt something might

be done by making dense smoke fires on frosty nights, but, unlike continental countries, it was very difficult in England to tell beforehand when these killing frosts might be expected. As regards destructive insect pests, he gathered from the reports of the observers that these were last year if anything less numerous than usual.

The PRESIDENT (Mr. R. BENTLEY) referred to the great labour entailed on Mr. Mawley in preparing these reports, and said it was not only the 15 years shown in Table I., but probably 17 or 18 since Mr. Mawley had first undertaken their production. With each year the figures increased in value, and he hoped the Fellows of the Society would carefully collate them with the curves of temperature, sunshine, and rainfall for each season. He could endorse what had been said about the destruction of buds and blossoms by small birds, for in Buckinghamshire they had wrought considerable damage, especially the bullfinches and sparrows. He thought it would be of immense value if accurate forecasts of frosts in the spring months could be established in this country. He had note of one such forecast in California which, by the farmers taking the necessary precautions, had been the means of saving thousands of dollars. The remarks made by the Fellows on the Phenological report gave a further interest to the report just read. The best thanks of the Society were due to Mr. Mawley, his staff of observers, and also to those who had taken part in the discussion.

Highest Kite Ascension.

Prof. C. F. Marvin, in a note in the *Monthly Weather Review, Washington*, for November 1905, says:—From a note in *Das Wetter* for November 1905, p. 262, we learn that an extreme elevation of 6430 metres, or 21,096 feet—that is, almost exactly 4 miles—was attained at the German Aeronautical Observatory at Lindenberg by means of a series of six kites. The record from automatic instruments sent up with the kites showed a drop in temperature from 40°·8 F. at the ground to −13° at the highest point. The wind velocity in the lower strata was about 18 miles per hour, and at the highest elevation 56 miles per hour.||

The Aeronautical Observatory under Dr. Assmann has been in operation only a few years, and yet has made wonderful progress in the meteorological exploration of the upper air by means of kites and balloons. A few years ago it seemed almost as if elevations of from 2 to 2½ miles were the limiting elevations for kite ascensions. The present accomplishment under Dr. Assmann is the more noteworthy from the fact that the kites were flown on land, where everything depends upon the natural wind. Heretofore, several incredibly high ascensions have been made at sea from the deck of steam vessels at the command of Teisserenc de Bort. The ability to direct the speed and motion of the vessel to give the best conditions for the flight of the kites constitutes a decided advantage over ascensions made on land from stationary reels, etc.

In the German ascension the note states that six kites were employed, having an aggregate area of 323 square feet, and that 47,572 feet of wire (about 9 miles) were suspended in the air.

The size or sizes of the wire employed, the form and structural details of the kites, and their dispositions on the line, together with data in regard to the average tension of the wire, all constitute important details of this distinct engineering achievement that would be highly interesting to aeronautical students. None of these are given in the note referred to, but it is hoped that they will appear in due time in the reports of the observatory.

Australian Meteorology.

The proposal for the creation of a Commonwealth Meteorological Department and Weather Bureau is still under consideration. Mr. Groom, Minister for Home Affairs, stated in the House of Representatives to-day that the Federal Government would again communicate with the State Premiers to see to what extent, in view of the report of the Inter-State Astronomical Conference, it would be practicable to establish a Federal department. A Bill was in preparation with a view to introduction, if possible, this session.—*Sydney Daily Telegraph*, August 9, 1905.

Earth Temperatures and Deep Level Mining.

At a meeting of the Institution of Mining and Metallurgy held on March 15, Mr. Hugh F. Marriott read a paper dealing with the records of an investigation of earth temperatures on the Witwatersrand Goldfields and their relation to deep level mining.

The author pointed out that the Witwatersrand area possessed peculiar advantages for the estimation of deep level temperatures owing to the existence within a limited area of outcrop mines, deep level workings, and boreholes which penetrated the strata to great depths. The records taken showed that the proportionate increase of temperature at depth varied very greatly in different localities, but the details of the observations proved conclusively that the increase of temperature was in direct proportion to the depth. Upon this law the estimate of mean earth temperatures was based and worked out at 1° F. for each 208 ft. increase in depth, or ·48° increase per 100 ft. of depth.[1] Starting from the mean temperature of 1000 ft. depth, which was 68°·75, the following figures were obtained:—2000 ft., 73°·55; 3000 ft., 78°·35; 4000 ft., 83°·15; 5000 ft., 87°·95; 6000 ft., 92°·75; 7000 ft., 97°·55; and 8000 ft., 102°·35. The experiments showed that the natural ventilation of mines decreased the rock temperature in the vicinity of the workings by 10° F., and this action became more marked in the deeper levels. The whole evidence obtained went to prove an extraordinarily uniform and moderate rate of increase of temperature in depth in this part of the earth's surface, and the practical deductions to be made therefrom were of great interest to the mining industry. The best type of instrument for the experiments was found to be a quick-acting thermometer of similar design to the ordinary clinical thermometer which gives the *maximum* temperature recorded.—*The Times*, March 21, 1906.

Temperature and Labour.

Mr. P. Lyttelton Gell writes with reference to the statistics published in the *Engineering Supplement* of March 21 as to the progressive temperatures experienced in the deep levels of the Rand, which he says merit the attention of politicians who oppose the employment of Asiatic labour under the impression that it displaces British miners. He points out that the Rand is in the latitude of Cawnpore. Its altitude, as is well known, moderates the climate which is commonly associated with such latitudes. But altitude does not extinguish the force of the sun, to which fact soldiers who fought at the Modder River and on many other fields can testify. The natural temperature of the mines is 68°·75 F. at 1000 ft. deep. It rises 4°·8 per 1000 ft. to 88° at 5000 ft., the highest temperature ascertained being 102°·35 at 8000 ft.[1] Such heat can, of course, be mitigated by artificial means, but no amount of fresh air drawn from the hot upper surface could reduce temperatures to a point at which British miners can toil permanently without detriment to health and stamina.—*The Times*, March 28, 1906.

[1] The above values appear to need comparison with the results obtained by other authorities elsewhere.—EDITORS.

BRIEF DISCUSSION OF THE GENERAL FEATURES OF THE PRESSURE AND WIND CONDITIONS OVER THE TRADES-MONSOON AREA.

By W. L. DALLAS.

[Read February 21, 1906.]

At the close of 1904, Dr. Walker, Meteorological Reporter to the Government of India, decided to publish an *Atlas* showing the meteorological conditions over the Trades-Monsoon area. This necessitated the collection and tabulation of all the marine observations which had been gathered together by the Indian Meteorological Department for the Indian Seas for the years 1893 to 1903, and the mean results are given in a series of monthly charts in the *Atlas* referred to.

While these monthly charts show in detail the mean monthly surface distribution of pressure, the mean direction and force of the wind, etc., over the surface of the seas, the collection of the data together appeared to afford an opportunity for a brief discussion of the general features of the pressure and wind conditions, which, though interesting from a scientific point of view, would be out of place in a meteorological atlas designed primarily for the practical use of mariners.

The observations employed in the following discussion are:—(1) the monthly means of 8 a.m. pressure corrected for temperature, for the height of the barometer above sea-level, and to constant gravity (lat. 45°); and (2) the mean monthly force of the wind (computed according to Beaufort's scale) recorded at 8 a.m. by ships traversing the Indian Seas.

The monthly means of the above elements were computed for areas of 4° of lat. by 4° of long., and the whole region for which data were collected extended from lat. 32° N. to lat. 12° S., and from long. 40° E. to long. 104° E.

Collecting the whole of these 4° area means together to form a general mean for the whole region, monthly values were obtained which are shown in Fig. 1 and in the following table:—

TABLE I.—Mean Monthly 8 a.m. Pressure of the whole Trades-Monsoon Area.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
29·913	29·876	29·826	29·785	29·752	29·686	29·681	29·702	29·770	29·826	29·869	29·90[illegible]

The monthly pressure means of the whole region thus exhibit a single oscillation during the year. The mean pressure falls from 29·913 ins. in January to 29·681 ins. in July, and then rises again to its maximum in January. That the annual pressure oscillation is single and not double is apparently due to the fact that of the area under discussion only 12° of lat. lie to the south of the equator, while there are 30° of area to the north of the equator. The observations to the north of the line thus possess an undue weight in determining the annual march of pressure for

the whole area. This undue weight of the northern observations is further intensified by the presence of the land surface of Southern Asia on the northern boundaries of the northern portion of the area under discussion, while there exists an uninterrupted oceanic surface over the southern portion of the area. In consequence, not only does the annual

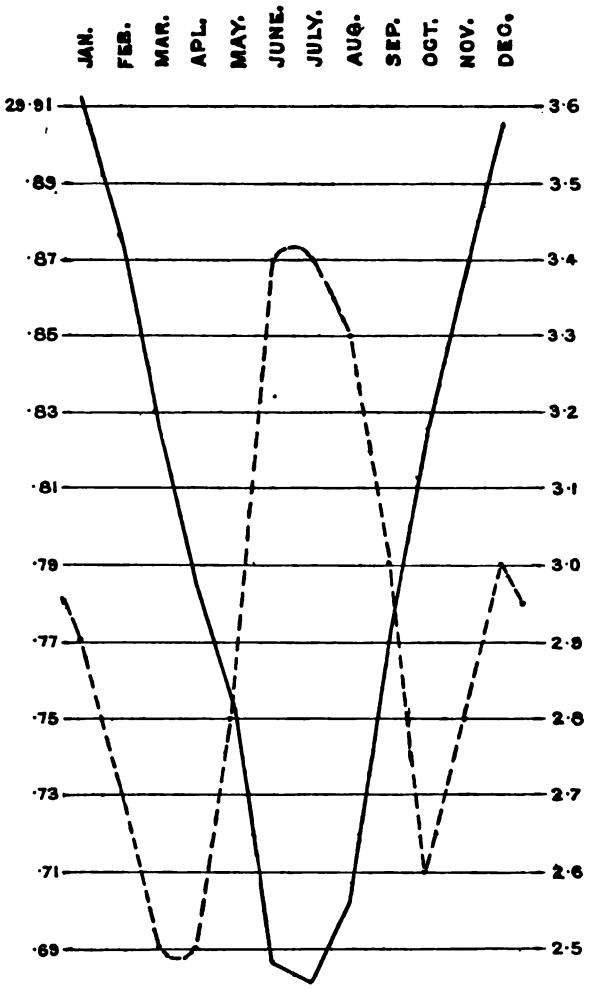


FIG. 1.—Mean Pressure and Wind-Force of the Trades-Monsoon Area.

Pressure-curve ———— Wind-Force curve – – – – – –

march of pressure exhibit a single in place of a double oscillation, but both the winter maximum and the summer minimum of pressure are of greater intensity than would otherwise have been the case. If in place of employing the monthly means of pressure of the whole area only those for the oceanic equatorial zones be used (lat. 4° N. to lat. 4° S.), the following figures are obtained :—

TABLE II.—Mean Monthly 8 A.M. Pressure of the Equatorial Zone.

Months.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Lat. 4° N. – 0°	29·897	29·912	29·884	29·865	29·868	29·869	29·885	29·890	29·902	29·905	29·907	29·906
0° to lat. 4° S.	29·884	29·907	29·884	29·874	29·886	29·895	29·923	29·906	29·939	29·922	29·924	29·901

In this series of means the single annual oscillation of pressure has disappeared, but the double oscillation which would, not unnaturally, have been expected to prevail, considering that the sun in its course between the tropics twice swings across these zones, is far from being clearly defined. In both zones there occurs a minimum in April, but there is no corresponding minimum in October, nor do the pressure maxima occur at the solstices.

The monthly means of the whole area shown in Table I. when treated by the ordinary harmonic formula to those terms—

$$a_e = Z_1 m_e \cos \theta_e + Z_1 N_e \sin \theta_e$$

gave the following smoothed values or means for the different months of the year :—

TABLE III.—Mean Calculated Monthly 8 A.M. Pressure of the whole Trades-Monsoon Area.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
29·914	29·875	29·822	29·789	29·746	29·692	29·674	29·707	29·767	29·827	29·871	29·904

These calculated values show no important differences from the crude means, the mean maximum pressure of the air occurring in January and the mean minimum in July. From the above data the table of mean monthly changes has been constructed :—

TABLE IV.—Changes of the Mean Pressure of the whole Area between one Month and the next.

Jan.-Feb.	Feb.-Mar.	Mar.-April.	April-May.	May-June.	June-July.	July-Aug.	Aug.-Sept.	Sept.-Oct.	Oct.-Nov.	Nov.-Dec.	Dec.-Jan.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
·039	·053	·033	·043	·054	·018	·033	·060	·060	·044	·033	·010

The pressure changes from one month to the next are much less symmetrical than might have been expected. The smallest changes occur at the two solstices, *i.e.* between June and July, and between December and January, while the largest changes occur roughly between May and June in the vernal, and between September and October in the autumnal period. The variations in the magnitude of the monthly pressure changes

are apparently the direct result of solar action. The sun in its course reaches the northern tropic on June 21, so that in June and July the sun's vertical position is approximately the same, the sun slowly advancing towards and retreating from the tropic during these two months.

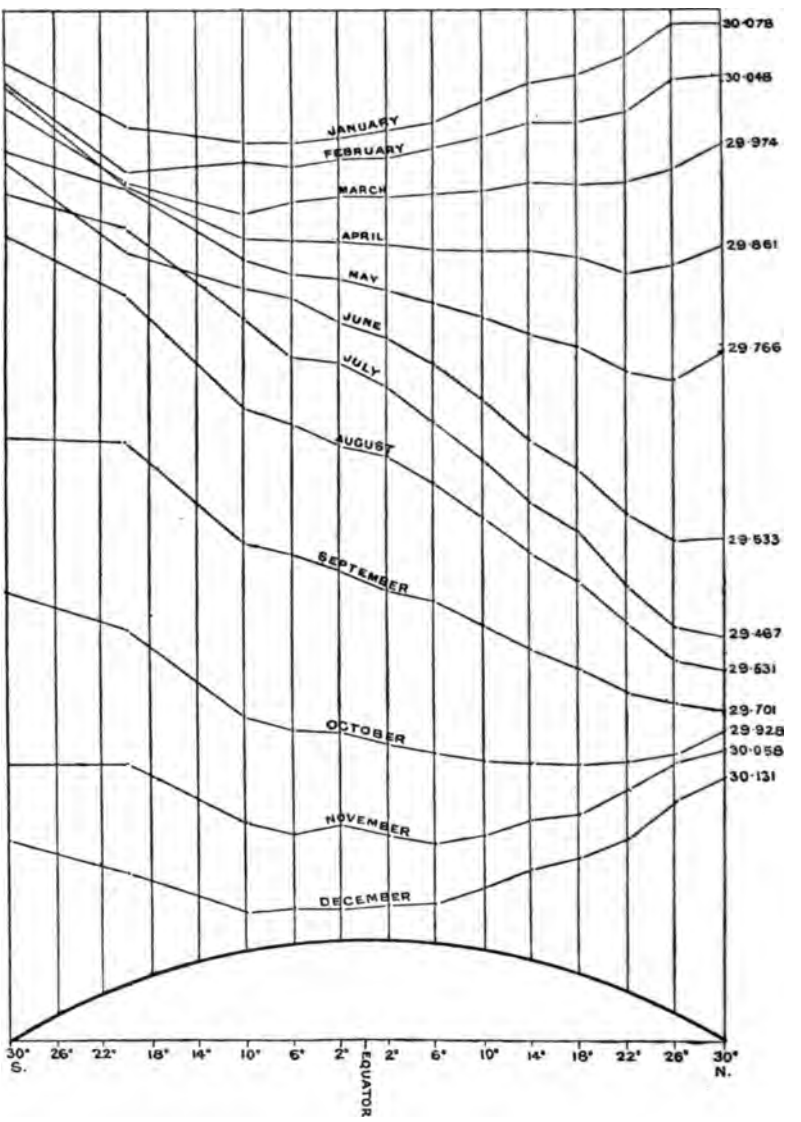


FIG. 2.—Monthly Pressure Curves between Lat. 30° N. and Lat. 30° S.

Similar conditions prevail at the southern tropic in December and January, and the pressure changes between these pairs of months are in consequence very small. On the other hand, the large pressure changes between May and June and between August and October are the result

of the large temperature changes taking place over the land surface of Southern Asia.

Table V. and the curves on Fig. 2 show the normal general pressure conditions prevailing along any longitude between lat. 30° S. and lat. 30° N. The pressure data for the extreme southern latitudes have been obtained by including the mean monthly pressures (corrected) of Mauritius, as given in the *Annual Reports of the Royal Alfred Observatory* (lat. 20° 6′ S.), and the mean pressures of lat. 30° S. as given in the *Monthly Charts of the Southern Ocean*, published by the Meteorological Office, London.

The preceding data exhibit less agreement between the sun's position and the distribution of pressure than might have been anticipated, the pressure changes lagging behind the solar changes to a considerable extent. Thus the lowest pressures in January are shown over lat. 6° S., while about the middle of January the sun is vertical in lat. 21° S.; the lowest pressures in February are reported from lat. 22° S., while the sun is vertical in lat. 14° S.; the lowest pressures about the middle of March are in lat. 10° S., while the sun is vertical in lat. 4° S. Between the middle of March and the middle of April the action of the sun in heating the land surface of southern Asia becomes apparent, and causes the area of lowest pressure to advance quickly northward, far outstripping the solar movement. As a consequence, in the middle of April the lowest pressures are reported from lat. 22° N., while the sun's vertical position is in lat. 12° N. In May and June the area of lowest pressure is reported from lat. 26° N., and in July, August, and September, from lat. 30° N., so that for these five months the area of minimum pressure lies far to the north of the sun's vertical position. In October the low-pressure area tardily follows the sun in its retreat southward, and is shown in the middle of the month over lat. 18° N., the sun being vertical at the time in lat. 11° S. By mid-November the low-pressure area has reached lat. 6° N., the sun being vertical in lat. 19° S., and in mid-December the lowest pressures are shown in lat. 10° S., the sun being then close to the Southern Tropic.

The curves in Fig. 2 show graphically the distribution of pressure over the Trades-Monsoon area in a north and south direction. In January, February, and March, and again in November and December, the curves exhibit a saucer-shaped form with the lowest pressures roughly between the equator and lat. 10° S., and relatively high pressures in lat. 30° N. and 30° S. There are, consequently, gradients for Northerly winds between lat. 30° N. and the equator, and for Southerly winds between lat. 30° S. and lat. 10° S. In April the distribution begins to change. There comes into existence then a fairly steady decrease of pressure from lat. 30° S. as far north as lat. 22° N., and the high-pressure area in lat. 30° N. has become very slight and unimportant. In May, June, July, and August, these features of the distribution are maintained and intensified, and there exists a steady barometric gradient for South to North air movement from lat. 30° S. to lat. 30° N. In September the amount of the gradient diminishes though the general features of the pressure conditions remain unchanged, but in October the saucer-shaped distribution of pressure is reappearing, and in November becomes fully developed.

The monthly range of pressure over the Trades-Monsoon area (shown in the last column of Table V.), exhibits a double oscillation. The first

TABLE V.—MEAN MONTHLY 8 A.M. PRESSURE.

Months.	Latitudes. South. 30°	26°	22°	18°	14°	10°	6°	2°	North. 2°	6°	10°	14°	18°	22°	26°	30°	Range.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan. .	30·010	29·957	29·903	29·895	29·887	29·879	29·877	29·884	29·897	29·912	29·946	29·978	29·991	30·020	30·075	30·078	·201
Feb. .	30·036	29·962	29·887	29·892	29·897	29·902	29·896	29·907	29·912	29·924	29·945	29·973	29·972	29·987	30·041	30·048	·161
Mar. .	30·036	29·973	29·909	29·891	29·874	29·857	29·878	29·884	29·884	29·886	29·895	29·910	29·906	29·910	29·930	29·974	·179
April .	30·130	30·048	29·966	29·936	29·906	29·876	29·874	29·874	29·865	29·859	29·856	29·855	29·845	29·818	29·833	29·861	·312
May .	30·100	30·070	30·039	30·000	29·960	29·920	29·897	29·886	29·868	29·846	29·822	29·796	29·776	29·734	29·718	29·766	·382
June .	30·160	30·087	30·014	29·994	29·974	29·954	29·937	29·895	29·869	29·823	29·764	29·699	29·649	29·575	29·528	29·533	·632
July .	30·210	30·182	30·154	30·103	30·052	30·001	29·936	29·923	29·885	29·828	29·762	29·694	29·643	29·552	29·481	29·467	·743
Aug. .	30·260	30·210	30·160	30·099	30·036	29·973	29·942	29·906	29·890	29·843	29·784	29·724	29·680	29·609	29·546	29·531	·729
Sept. .	30·160	30·158	30·156	30·097	30·039	29·981	29·964	29·939	29·902	29·883	29·843	29·804	29·776	29·732	29·715	29·701	·459
Oct. .	30·160	30·127	30·095	30·047	29·999	29·951	29·928	29·922	29·905	29·889	29·878	29·873	29·870	29·876	29·892	29·928	·290
Nov. .	30·030	30·030	30·030	29·996	29·962	29·928	29·910	29·924	29·907	29·895	28·908	29·935	29·943	29·987	30·035	30·058	·163
Dec. .	30·020	29·991	29·962	29·940	29·919	29·898	29·902	29·901	29·906	29·911	29·940	29·973	29·992	30·023	30·087	30·131	·233

minimum occurs about the end of February (·161 in.). The range increases throughout March, April, May, and June, and reaches its maximum

shortly after the middle of July, when it amounts to ·743 in.; it then decreases during August, September, and October, and reaches its second minimum in November (·163 in.), after which it rises to its secondary maximum (·233 in.) in December.

Turning next to the air movements which accompany these pressure changes, Table VI. and Fig. 1 show the mean wind-force for the whole region for each month.

TABLE VI.—MEAN WIND-FORCE (8 A.M.) OF THE WHOLE TRADES-MONSOON AREA.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
2·9	2·7	2·5	2·5	2·8	3·4	3·4	3·3	3·0	2·6	2·8	3·0

The preceding data and the curve in Fig. 1 show that, as was the case with the pressure range, a double annual oscillation exists in this element. The first minimum (2·5) occurs in March. The force increases during April, May, and June, and the first maximum (3·4) is reached at the end of June. The force decreases through July, August, and September, and the second minimum is reached in October, after which the force increases again to the second maximum in December.

The minimum wind forces are thus recorded at the equinoxes when the sun and the lowest atmospheric pressures are shown over the equatorial zone. There is at these epochs a flow of air from more northern and from more southern latitudes towards the equator, where ascensional movements presumably take place. The air currents, consequently, at these two seasons flow over relatively short distances, and from regions of narrow longitudinal degrees to a region of wide longitudinal degrees. Hence the aerial currents are, to a certain extent, in a situation similar to that of a stream of water confined by constantly widening banks, and the tendency is for the general movement to become more and more sluggish as the air advances.

The maximum wind forces are recorded at the solstices. At the time of the Cancer solstice there exist over the Trades-Monsoon area a steadily decreasing barometric pressure from lat. 30° S. to lat. 30° N., and an uninterrupted flow of air from the former to the latter region. In addition, over the greater part of the region under discussion the air is moving forward over a constantly contracting area, so that notwithstanding the freedom of the air to ascend, it is possible that this condition increases the velocity already arising from the large pressure differences.

Table VII. shows the mean wind conditions prevailing along any longitude between lat. 10° S. and lat. 30° N.

The data are much less complete than those given in the corresponding pressure Table V., as it was found impossible to determine, even approximately, the mean wind-force of lat. 30° S. from the *Meteorological Charts of the Southern Ocean*, while the monthly mean converted forces for Mauritius are probably hardly comparable with the forces directly recorded over the open sea. Hence the rough interpolation, which was fairly satisfactorily carried out in the case of pressure, proved not to be feasible in the case of wind-force.

TABLE VII.—MEAN MONTHLY 8 A.M. WIND-FORCES.

MONTHS.	LATITUDES.															
	South.								North.							
	30°	26°	22°	18°	14°	10°	6°	2°	2°	6°	10°	14°	18°	22°	26°	30°
January	No observations.	No observations.	2·2*	No observations.	No observations.	2·9	2·8	2·8	3·1	3·7	3·6	3·4	3·0	2·9	3·5	3·4
February			2·2			2·7	3·0	2·8	2·9	3·5	3·2	3·1	2·8	2·7	3·2	3·0
March			1·8			2·4	2·4	2·5	2·6	2·6	2·5	2·8	2·6	3·0	3·0	3·2
April			2·0			3·3	2·6	2·5	2·4	2·4	2·4	2·6	2·7	3·0	2·7	2·8
May			2·0			3·8	3·1	2·6	2·8	3·3	3·1	3·0	2·9	3·8	2·8	2·7
June			2·2			3·9	3·5	2·9	3·2	4·2	4·5	4·2	4·1	3·9	2·8	3·3
July			2·3			4·3	3·8	3·4	3·4	3·9	4·5	4·5	4·5	3·7	2·8	1·9
August			2·5			4·5	3·9	3·2	3·1	3·8	4·3	4·1	4·0	3·6	2·6	2·5
September			2·4			4·6	3·7	2·9	3·1	3·5	3·5	3·4	3·1	2·9	2·7	2·8
October			2·0			3·5	3·4	2·9	3·0	2·9	2·7	2·8	2·7	2·7	2·3	2·5
November			2·0			3·5	2·7	2·6	3·0	2·9	3·1	3·4	3·3	2·6	2·7	3·2
December			2·0			3·1	2·9	2·9	3·0	3·5	3·7	3·7	3·4	3·0	2·9	3·5

* Mauritius wind-velocity normals converted to Beaufort Scale forces.

Notwithstanding these limitations the recorded observations are not without interest. The region of least horizontal movement, and hence, probably, of greatest ascensional action in January, lies in lat. 6° S., where atmospheric pressure also is lowest. In February the region of least horizontal movement has been transferred southward and lies outside the area of observation, probably in about lat. 22° S., where pressure is lowest at this season. In March the area is shown between lat. 10° and 6° S., the lowest atmospheric pressures being reported at the same time over lat. 10° S. In April there occurs a sudden movement northward of the area of least horizontal movement, which is shown lying over lat. 2° N. to 10° N. The area of least movement no longer even approximately coincides with the area of lowest atmospheric pressure, the latter being shown in April as far north as lat. 22° N. During the prevalence of the monsoon—from May to September—the mean wind-forces exhibit an interesting characteristic, which is apparently fairly constant throughout the season. The wind blows moderately strongly in lat. 10° S. (forces 3·8 to 4·6), but, as the current flows northward over the constantly extending area of the earth's surface, the force decreases, and over the equatorial zone itself becomes relatively low (forces 2·6 to 3·4). North of lat. 2° N. the force increases again up to lat. 10° N. (forces 3·1 to 4·5). To the north of lat. 10° N. the steady stream line movement of the circulation ceases, eddies and ascensional movements take place in the current, the force at the same time diminishing gradually up to lat. 26° or 30° N., where the atmospheric pressure is lowest and the main ascensional movements take place over a heated land surface.

In October the mean wind forces are fairly uniform throughout the different zones. Both in November and December the principal area of weak horizontal movement is shown over lat. 6° and 2° S., but for some reason the movement is almost equally weak in lat. 22° and 26° N.

In several of the *Annual Reports on the Meteorology of India*, as well as in the *Annual Memoranda on the Snowfall and Meteorology of India*, will be found discussions on the Trades-Monsoon circulation, and certain attributes

are assigned to it which would, to a great extent, differentiate this circulation from other atmospheric currents. Thus it is stated that the movements of the current are due to an impulse in one spot, so that apparently the Trades-Monsoon current advances from south to north after the manner of a jet of steam issuing from a closed reservoir. These views are put forward in the *Memorandum*, dated June 4, 1891, in the following words :— "Hence the advance or extension (or burst of the monsoon) takes place from south to north, and therefore cannot be explained as a mere indraught to a hot area. The phenomena rather indicate that there is a vast resistance or obstruction to be overcome, and that when this is overcome by a force from the rear (*vis a tergo*) the massive current moves forward comparatively rapidly and invades India."

To test this description of the movements of the current Table VIII. has been compiled, showing the differences of barometric pressure from zone to zone and their associated wind-forces.

TABLE VIII.—Barometric Gradient or Pressure Difference between Zone and Zone and Mean Wind-Force.

		14° S. to 10° S.	10° S. to 6° S.	6° S. to 2° S.	2° S. to 2° N.	2° N. to 6° N.	6° N. to 10° N.	10° N. to 14° N.	14° N. to 18° N.	18° N. to 22° N.	22° N. to 26° N.	26° N. to 30° N.
May	Press. diff.	·040	·023	·011	·018	·022	·024	·026	·020	·042	·016	+·048
	Wind-force	3·8	3·1	2·6	2·8	3·3	3·1	3·0	2·9	3·8	2·8	2·7
June	Press. diff.	·020	·017	·042	·026	·046	·059	·065	·050	·074	·047	+·005
	Wind-force	3·9	3·5	2·9	3·2	4·2	4·5	4·2	4·1	3·9	2·8	3·3
July	Press. diff.	·051	·065	·013	·038	·057	·066	·068	·051	·091	·071	·014
	Wind-force	4·3	3·8	3·4	3·4	3·9	4·5	4·5	4·5	3·7	2·8	1·9
Aug.	Press. diff.	·063	·031	·036	·016	·047	·059	·060	·044	·071	·063	·015
	Wind-force	4·5	3·9	3·2	3·1	3·8	4·3	4·1	4·0	3·6	2·6	2·5

The above data show that the observations at present under discussion do not afford any evidence of the tempestuous, obstacle overcoming onslaught from the south to the north described above. The Trades-Monsoon current does not appear to be controlled by a single initial impulse, but, on the contrary, its velocity of advance is governed by the continual gravitative acceleration common to all aerial circulations. In May the pressure difference for 4° between lat. 14° S. and 10° S. is ·040 in., and the mean wind-force of the zone is 3·8. The pressure differences decrease steadily between lat. 14° S. and lat. 2° S., and so also do the mean wind-forces. Between lat. 2° S. and lat. 18° N. the pressure differences are very constant and the wind-force steady between 2·8 and 3·3, while between lat. 18° and 22° N. the pressure difference increases to ·042 in. and the mean wind-force to 3·8, while between lat. 22° and 26° N. the pressure difference decreases to ·016 in. and the mean wind-force falls to

2·8. Between lat. 26° and 30° N. the pressure difference becomes considerable, but the direction of the barometric gradient is from north to south, or the opposite of that prevailing over other parts of the area, and the air movement is over a land surface.

This general agreement between the pressure differences and the mean force of the wind obtains throughout the whole area and throughout the whole monsoon period, and the velocity or strength of the winds of the circulation appears to be regulated by the ordinary rules of differences of barometric gradient, and not, at any time, by a single impulse imported to the rear of the aerial current.

DISCUSSION.

Capt. M. W. C. HEPWORTH (in a note to the Secretary) said :—"There are several points in Mr. Dallas's Paper upon which I should have offered some remarks had I been able to be present at the meeting.

"Principally I should have pointed out, in connection with what Mr. Dallas says regarding the burst of the south-west monsoon, the effect produced by the sudden alteration in the course of the equatorial current at the end of March or the beginning of April.

"During the period of the north-east monsoon (more correctly north-east trade) the set of the surface water in the North Indian Ocean is mainly toward the west, and the equatorial current is diverted to the south. With the failure of the north-east monsoon and simultaneous increase in volume and extent of the south-east trade-wind of the South Indian Ocean the warm equatorial current is let loose and flows to the north-eastward. In April it has raised the temperature of the surface water in the Arabian Sea and Bay of Bengal, especially in the latter, very considerably (I have not the figures by me).

"To a steady diminution of atmospheric pressure over the land areas, due to a rise of temperature, is now added, rather suddenly, a reduction of pressure over the adjoining seas; what wonder, then, that the south-west monsoon, when it asserts itself, should come as a cataclysm.

"Other points in the paper inviting discussion will doubtless be dealt with by Fellows present and in a more able manner. I welcome Mr. Dallas's contribution on the subject, for the meteorology of the Indian Ocean has been occupying the attention of the Meteorological Office for some years past."

THE PRESIDENT (Mr. R. BENTLEY) said that the general theory of atmospheric circulation had been laid down by such meteorologists as Halley, Hadley, Reid, Piddington, Ferrel, and Loomis, all of whom had done work of great value in amplifying our knowledge of the movements of the air, and had prepared the way for further investigations by means of kites and balloons which were now being undertaken in various countries. Only recently Dr. Shaw had shown a connection between the variation of the trade-winds at St. Helena and the rainfall in the south of England ("The Pulse of Atmospheric Circulation," *Nature*, December 21, 1905), and when we had the Indian Atlas of Meteorology referred to by Mr. Dallas our knowledge would be still further added to.

THE DISPERSAL OR PREVENTION OF FOGS.

By WILLIAM B. NEWTON, Ph.D., F.C.S.

[Read February 21, 1906.]

FORTUNATELY fogs are not always with us. But almost invariably in November and December, and sometimes other winter months, fogs occur of such density as to paralyse the traffic and put up the death-rate to an alarming extent.

Considering the very large monetary loss, besides other damage, caused by fogs, it is somewhat surprising that so few attempts have been made to remedy this evil.

The stupendous nature of the phenomenon has deterred men from attacking the problem, and indeed one risks a little ridicule in suggesting a remedy. But in these days when science has found the way to train one force of Nature against another, we need not despair of accomplishing apparently impossible tasks when the proper scientific investigation is brought to bear on them. Sir Oliver Lodge has been partially successful in dissipating fog over a small area by high-tension electricity. The ultimate remedy I think, however, will be simpler and more effective.

Let us consider scientifically the nature of fog and its origin. We must put out of consideration those irritating concomitants of a fog when the fog occurs over a large city, those noxious fumes and gases blanketed and held down, and thus prevented from escaping into the higher atmosphere.

These noxious fumes have a serious action on the health, but they are not the fog, only one of its objectionable effects.

There is, however, one particularly irritating concomitant of "town fogs" which must be mentioned here. I refer to the floating solids in the fog. On careful investigation of fog both microscopically and by chemical analysis, the solids are found to consist almost entirely of minute feathery particles of carbon, or rather soot, consisting chiefly of carbon with a slight film of oily matter. These are, of course, the emanations of the chimneys in the area affected by the fog. Owing to the small amount of oil which surrounds these particles, they cannot become wetted by the mist, and therefore they do not fall rapidly, but, on the other hand, they have little power to rise through the blanket of fog. Consequently they form a nauseous, slowly-falling stratum which considerably adds to the obscurity of the fog.

Their distinct character can be seen on filtering the air, the collected solids showing their jet black, sooty origin, in contrast to the greyish, fine organic and mineral matter which preponderates in ordinary atmospheric dust.

In a recent lecture (Prof. Oliver, "The Harben Health Lectures" 1905) it was stated that motor cars are partly the cause of fogs by the dust they raise. This is not so. This sin, at least, cannot be placed to the account of the much maligned motor cars, for in foggy weather they are invariably travelling through mud or over ice-bound roads.

Apart from these emanations from towns (emanations which naturally are retained and concentrated the more the greater the duration and

density of the fog), fogs or clouds are the same thing, that is, parts of the atmosphere supersaturated with aqueous vapour.

Accepting this contention as a fact that fog and cloud are the same, and I think it can scarcely be disputed, let us see how clouds are dispersed and dissipated, and it will lead us to the means which can disperse fogs.

Clouds can be dispersed in three ways. Firstly, by the heat of the sun causing a rise of temperature in the atmosphere, and therefore giving the air a greater power of absorbing moisture. Secondly, by coming in contact with the tops of hills and mountains where the clouds drop their moisture as dew. Thirdly, and chiefly, clouds are dissipated by their moisture turning into rain-drops and descending to the earth.

Now air saturated with aqueous vapour does not allow that vapour to coalesce into drops unless particles of dust are present. This has been proved with steam in dust-free air, and by other experiments by Coulier and Mascart in France and John Aitken in England.

Prof. Russell Wallace in the last (1903) edition of his book, *The Wonderful Century*, states the cause of rain very clearly. He says, p. 184, "If there were absolutely no particles of solid matter in the upper atmosphere, all the moisture would be returned to the earth in the form of dense mists or copious dews, which in forests would form torrents of rain by the rapid condensation on the leaves"; and p. 185, "The chief mode of discharging the atmospheric (water) vapour in the absence of dust would, however, be by contact with the higher slopes of all mountain ranges." "The mere cooling of vapour in air will not condense it into mist-clouds or rain unless particles of solid matter are present to form nuclei upon which condensation can begin."

The height at which clouds only exist is because if by their gravity they descend into the lower dusty atmosphere they dissipate themselves, coming down to the earth as rain.

The action of the microscopic dust particles in the atmosphere is as follows:—Immediately a molecule of aqueous vapour concentrates on them into liquid the power of the little mass is increased to attract further particles of water, till it becomes a rain-drop and begins to fall, carrying with it in its path all the aqueous vapour it comes in contact with. Now how and when do fogs occur? After the heavy rains of October and November the dust is completely washed out of the atmosphere, and the soil is so sodden with water that no fresh dust rises, and the mist has no solid points upon which to concentrate and turn into rain. The consequence is, the clouds can come down to the ground level and are then called fogs. There is no reason why after heavy and continuous rains the dust should not be artificially restored to the atmosphere to give points on which these mists and fogs could coalesce and deposit themselves as rain. The amount of dust in the atmosphere which starts the rain is as a rule not large when very fine, being usually not more than a few pounds to a square mile. If this amount were fired into the atmosphere by guns, shells, or rockets, or distributed by other means, rain would immediately be produced and the fog would disappear. Probably, at first, shells or rockets with light paper casings will be the means of doing this, but eventually we may find that air-ships may have their first practical use in distributing dust over the foggy area. The absence

of wind, which is usual under foggy circumstances, is the most favourable weather for the use of air-ships and suitable for their action. Whether County Councils will use these means for distributing dust over a foggy area, as they send water-carts over dusty roads, or whether they use dust-rockets or guns, there is no doubt that in the future dust will be used to lay the water, just as water is now used to lay the dust.

Fortunately the expense of the process for laying the fog is very slight, and the large towns and seaports can afford to pay well for the removal of an evil which costs them annually millions of pounds in damage, not to mention the serious detriment to health which cannot be represented in money value.

Postscript.

I meant to remark about rain, after battles and earthquakes. Some people have even been so foolish as to suggest "that the perspiration of the fighting men goes up and comes down as rain."

It is only the cyclone of dust caused by the artillery being brought up quickly. The detonation of cannon which "rainmakers" have relied on is no good without dust. If detonation would produce rain it would occur in the battle, not two or three hours later.

DISCUSSION.

Dr. W. N. SHAW (in a note to the Secretary) said: "As I am unable to be present at the meeting of the Society, I send a note about Dr. Newton's paper, because I think it would be a misfortune for the Society if the paper appeared in the *Journal* without some comment.

"I fear that the parts of the paper which may be called novel are based upon an inadequate acquaintance with the literature, facts, and theory of the subject. The author seems to suppose that dust coagulates droplets already formed. In the first place, there is no evidence that I know of for the coagulation of droplets in the air by any artificial process to form large drops, and, in the second place, it is the formation of the droplet which requires a nucleus. The fact that fog, which consists of droplets, is already formed is itself evidence of the abundance of nuclei for condensation. To suppose that the atmosphere of London is ever deficient in condensation nuclei must seem an absurdity to any one who has read Mr. Aitken's papers."

Mr. C. T. R. WILSON (in a note to the Secretary) said: "The paper appears to me to be based on a misunderstanding of the work of Aitken and others. Dust particles have not the action ascribed to them in the paper; there is not the slightest evidence that they assist fog particles to combine to form larger drops.

"Aitken's experiments prove that in the absence of dust particles quite a considerable degree of supersaturation may be brought about without any fog, cloud, or rain resulting—the water remaining in the gaseous condition for lack of suitable centres to condense upon. If dust particles are present a drop is formed upon each. The larger the number of dust particles the more numerous and consequently (a limited quantity of water only being available) the smaller are the droplets. The condition for getting a fog in such experiments, then, is that the number of dust particles shall be excessively great; if we wish, on the other hand, to get a shower of comparatively large drops, the dust particles must

be very few, so that the quantity of water falling to the share of each may be considerable.

"I can conceive of no more unlikely cause for fogs than a deficiency of dust particles.

"There is no reason to suppose that in the absence of dust particles rain would be a rare occurrence. There would still remain the *ions* which are continually being produced in the atmosphere, and on which condensation takes place so soon as a certain perfectly definite degree of supersaturation is exceeded."

Mr. R. INWARDS thought that it would have been better if Dr. Newton had tried the experiments before the paper had been brought before the Society.

Mr. C. HARDING inquired if the author had any preference for any particular kind of dust? There was always a superabundance of soot in the atmosphere during a fog.

Mr. D. W. HORNER thought that by carrying out the experiment the remedy might be worse than the disease. If any attempt was to be made at all, he thought it would have to be on the lines suggested by Sir Oliver Lodge, although the expense of such an undertaking was its great drawback. No doubt what we must look to for the cleansing of London fogs was the increased use of electricity for lighting and heating, thus eliminating the smoke element, but the fogs themselves, he feared, would be ever with us.

Mr. W. GREATHEED said that as we were under the influence of a prevailing South-west wind, the amount of carbon and dust particles that would be carried into the eastern counties would make those districts the wettest in the kingdom; but instead of that they were uniformly dry, some places having less rain than any other part of the country.

Mr. W. B. TRIPP said that during the blowing of the pampero in South America, one moment you were smothered in dust and shortly afterwards drenched with torrents of rain, the transition between these two being a fall of mud. He thought that such a thing might happen here on a small scale if Dr. Newton's experiment was carried out, and the fog might similarly become a shower of mud.

Lt.-Col. GILES remarked that dust storms were fairly common in India, but they were by no means generally followed by rain. After the eruption of Krakatoa dust particles in great quantities were sent all round the world, but he would like to know if the period following the eruption was a rainy one or not.

Mr. J. E. CLARK, though not at all accepting the author's views, thought the discussion was rather getting away from the point. You must first have the fog before putting the dust into it. With the air free of dust, the author did not suggest that rain would be produced by adding dust to it.

Mr. R. G. K. LEMPFERT said that most of the points which had occurred to him in listening to the paper had been dealt with in the letters which had been read from Dr. Shaw and Mr. C. T. R. Wilson. He desired, however, to dissent from the author's enumeration of the ways in which clouds were dispersed. The first method was no doubt effective up to a point, but some experiments of Dr. Shaw's, which had been shown before the Society on a previous occasion, showed that under certain circumstances it was possible to communicate heat to a cloud and thereby to increase its density. The second method was more open to criticism in that the general effect of air currents blowing against the slope of a hill was to cause the formation of cloud in consequence of dynamical cooling. As to the third method, there was no evidence for supposing that the water droplets in clouds coalesced, and so became heavy enough to fall rapidly to the ground. It was difficult to understand how the proposed method of adding to the nuclei already present in the air could bring about such a result. The most important cause of the dispersal of clouds, viz. that of the dynamical

heating of the air in descending air currents, had not been mentioned by the author.

Mr. D. A. Louis said that it seemed to him that Dr. Newton clearly understood the nature of fog. Fog was of the same character as a cloud, and could be dispersed in the same manner. The paper was an unfinished one and unaccompanied by experimental evidence, owing to Dr. Newton's sudden departure and continued absence from England, who, had he been present, would no doubt have been able to answer all the points that had been raised in the discussion. It was to be noticed that Dr. Newton had not stated the character of the dust to be employed in making the experiment, but he was of opinion that that omission too would be duly rectified. In his own chemical experience of air destitute of dust particles, and with saturated and supersaturated air, he had been able to make satisfactory demonstration of the experiments Dr. Newton referred to; that is, the moisture in the absence of dust neither formed clouds nor fog nor rain, but was simply deposited as a copious dew, and trickled down the walls of the chamber in which the dust-free saturated or supersaturated air was contained.

The President (Mr. R. Bentley), in conclusion, said there seemed to be a consensus of opinion against introducing dust particles into the air as a means of dispersing fog. In hospitals it was generally considered an important factor to have the air free of dust, and when this was done a marked improvement in health generally took place. Besides being very sceptical as to the result, he felt sure that the introduction of further irritant particles into the atmosphere —even if they were first sterilised—would be extremely unwelcome to all.

The Argentine Antarctic Stations.

The Argentine exploring ship *El Austral* left Buenos Ayres at the end of December, carrying with her a party of three scientists and a steward, under the direction of Señor Lind, to continue the work initiated by the Scottish National Antarctic Expedition, for a fourth year, at the meteorological and magnetical station at Scotia Bay, South Orkneys.

The ship *El Austral*, after landing this party, will return to Ushuwaia, Tierra del Fuego, from the South Orkneys, with the party which has been stationed there during the past year. Meantime Mr. Angus Rankin, late superintendent of the Ben Nevis Observatory, and three companions are on their way by mail steamer to Ushuwaia, where they will join *El Austral* and proceed southwards to Wandel Island, Graham's Land. Here Mr. Rankin will establish, at the south end of Gerlache Strait, south of 65° S. lat., a new Argentine Antarctic meteorological and magnetical station. On the return of *El Austral* to Buenos Ayres, another of the late Ben Nevis Observatory staff, viz. Mr. R. H. MacDougall, will be embarked for the island of South Georgia, where a third station is to be set up. This forms the largest and most important series of Polar meteorological stations working in co-ordination since the great international Polar project of 1882-83.—*Scottish Geographical Magazine*, March, 1906.

SYMONS MEMORIAL MEDAL, 1906.

(Plate III.)

THE presentation of the Symons Memorial Gold Medal for 1906 was made at the Annual General Meeting of the Society on January 18, the recipient being Lieut.-Gen. Sir Richard Strachey, R.E., G.C.S.I., F.R.S.

The PRESIDENT (Mr. RICHARD BENTLEY) expressed his regret that General Sir Richard Strachey was unable to attend in person on this occasion, adding, that much as the Fellows present would have wished this, they were still more reluctant that General Strachey should incur any risk through being exposed to the chill air of a January night.

"I have first," the President said, "to read out to you, in accordance with the regulations, the particulars of Sir Richard Strachey's services to Meteorology as they appear in the Minute Book of the Council:—

Gen. Strachey had a long career in India, in the course of which he filled several important posts, amongst which may be mentioned, as having a more or less direct bearing on Meteorology, those of Inspector-General of Irrigation from 1867 to 1871, and President of the Famine Commission from 1878 to 1889. But as a Member of the Indian Government, and also of the Council of the Secretary of State for India, he worked both energetically and persistently for the establishment of the system of meteorological observations which is now carried on by the Indian Government.

In 1884 he represented Great Britain at the Prime Meridian Conference at Washington.

In 1873 he became a Member of the Meteorological Council, and in 1883 its Chairman, a post he continued to hold until the Council ceased to exist in the spring of the year 1905.

He became a Fellow of the Royal Society in 1854, and he has twice filled the office of Vice-President. During 1888-90 he was President of the Royal Geographical Society, and President of the Geographical Section of the British Association in 1875.

In 1897 he received a Royal Medal from the Royal Society for "his investigations in physical and botanical geography, geology, and meteorology," his latest contributions to the last-named subject being specially mentioned as "the last of a long series of valuable memoirs."

He is the author of several works on geography—mainly on the physical side of the subject,—and also on geology and botany, much of his work having reference to the Western Himalaya and Tibet.

Amongst his numerous papers on Meteorological subjects may be mentioned:—

"Physical Causes of Indian Famines."

"On the Correspondence of the Rainfall at Madras with the Sun Spot Period; and the True Criterion of Periodicity in a Series of Variable Quantities."

"On the Distribution of Aqueous Vapour in the Upper Parts of the Atmosphere."

"Note on a Series of Barometrical Disturbances in 1883," a paper which had much to do with the subsequent investigation of the Krakatoa phenomena, in which Gen. Strachey discussed the Barometrical Disturbances and Sound Waves caused by the great volcanic eruption.

"The Action of Aqueous Vapour on Terrestrial Radiation."

"The Measurement of Cloud Heights."

LIEUT.-GEN. SIR RICHARD STRACHEY, G.C.S.I., F.R.S.
(*Symons Medallist*, 1906)

Approved for release by NSA on 07-22-2013 pursuant to E.O. 13526

"The Computation (1) of True Average Daily Means of Temperature from Daily Observations of Maxima and Minima; and (2) of Accumulated Temperature," in connection with which he suggested the use of "Day-degrees."

"The Application of Harmonic Analysis to Meteorological Phenomena."

"The Harmonic Analysis of Hourly Observations of Temperature at British Observatories."

As Chairman of the Meteorological Council, Gen. Strachey was the official representative of Meteorology in this country, and the recent termination of the Council presents a fitting opportunity for the Council of the Royal Meteorological Society to honour itself in honouring so distinguished a Fellow of the Society.

"Beside the long list—and that one illustrative of more conspicuous work than by any means a complete record—of valuable scientific investigation just recounted, I feel sure that I shall be pardoned for adding a few other details, even if not strictly meteorological, of Sir Richard Strachey's varied and distinguished career. He went out to the East in the 'forties, in the days of the Honourable East India Company, and participated in the great war which led ultimately to the incorporation of some of the finest fighting material in the world under the British flag. He was in the Sutlej Valley when the first Sikh War broke out in 1845, and took part in the victories of Sobraon under Lord Gough, and of Aliwal under Sir Harry Smith in January 1846, before very many of us present to-night were born, and was 'mentioned in despatches' and received the Sutlej medal. Later his services were chiefly administrative, and during the Mutiny of 1857 he was Secretary to the Government of the Central Provinces. General Strachey was subsequently a member of the Governor-General's Council, and at a still later date of the Indian Council. Besides his military and administrative work, he devoted part of his time to engineering work in connection with canals and irrigation work, while in another branch of science Sir Richard's researches in the flora of the Himalayas, some of which were undertaken in conjunction with Sir Joseph Hooker, were a very valuable addition to our botanical knowledge. General Strachey has been for thirty years on our Roll of Fellows, and we trust may be for a long time, having regard to the precedents of long life of Sir Christopher Wren, Luke Howard, Mr. Perigal, or Mr. Glaisher.

"In connection with this award of the Council our thoughts naturally turn to the great Meteorologist in whose memory this medal was instituted. Mr. Symons became a member of this Society at the early age of seventeen. He was twice its President—in 1880, and again in the Society's jubilee year, in 1900. The posts which he held both in this and in other Societies are in themselves an indication of his exceptional ability, but the attraction of his personal qualities is still more testified to by the ready enlistment of no less than three thousand voluntary workers to prosecute under his direction an inquiry into the rainfall of this kingdom. His patience, tenacity of purpose, and accuracy of research rendered this organisation one of the highest value, while his modest and genial nature endeared him to all who had the privilege of knowing him. The Gold Medal, which I now hand over to Dr. Shaw,—who will this evening receive it on behalf of Sir Richard Strachey,—bears on its obverse

a portrait of Mr. Symons. The previous recipients of it have been Dr. Buchan and Professor Hann."

Dr. W. N. SHAW, on receiving the Medal, said :—

"I have received the following letter from Sir Richard Strachey :—

69 LANCASTER GATE, W., *January* 11, 1906.

My dear Mr. Shaw,—As I am not in a condition that will admit of going to the General Meeting of the Royal Meteorological Society to receive the Medal that has been awarded to me, I hope that you will be so good as to appear in my place, and to express in my behalf my regret at not being able to be present, and state in person my sense of the great honour done me by the award of the Symons Medal.—Believe me, yours truly, R. STRACHEY.

"In complying with Sir Richard's request I can add to the expression of his regret that of my own at his inability to be present on this occasion. For the last nine years it has been my privilege to stand in close relationship with Sir Richard in meteorological matters, for eight years as a Member of the Council of which he was Chairman, and for five of them as its Secretary. I know something of the gratification which he feels at the Society's appreciation of his work for Meteorological Science. It is not for me to set out his claims upon the regard and consideration of his fellow-meteorologists, but in acknowledging the honour done him, it will not be out of place if I mention some of the guiding principles in regard to meteorological work which I have gathered from association with him in the Meteorological Office.

"First of all, width of view, a natural result perhaps of his own wide scientific and administrative experience. For him British Meteorology, Indian Meteorology, Ocean Meteorology, and the investigation of the upper air, were not in separate scientific compartments. As aspects of the study of a common process they must help each other if we would learn the secrets of the phenomena which are registered in a single locality whether on sea or land.

"Next, the paramount importance of long-continued series of properly organised observations. Meteorological phenomena, as examples of the application of physical laws, belong to the study of physics, yet meteorology in the modern sense is a new science. It requires not only material of a special kind which can be only gradually accumulated, but special methods suitable for dealing with it. In the organisation of the observations there is, on the one hand, the danger of being careless of accuracy or continuity, because the material cannot be utilised immediately, and, on the other hand, the danger of carrying the refinement of observations and their manipulation beyond the limits set by the inherent inaccuracy of the measurements.

"Thirdly, the necessity for dealing rather with the orderly variations which underlie the course of the phenomena than with the crude phenomena individually. We are not surprised to find a diurnal variation of temperature showing itself whenever the observations of a few days are grouped together, though it may be entirely masked on any individual day. For this underlying variation we can assign an obvious cause, but it is not by any means the only example of simplification by combination. The treatment of questions by groups of observations, rather than by single observa-

tions, is the special characteristic of the science of meteorology, and from this point of view the isolated phenomenon, the subject of the direct application of the reasoning of ordinary physics, may be the last to be approached by the successful meteorologist, and not the first.

"Two examples of this principle occur to me. One, the use of the methods of harmonic analysis has already found its effectiveness, for it has shown the existence of a periodic variation of the barometer, diminishing in magnitude from the equator polewards, but following the sun with remarkable fidelity, and taking place simultaneously round the whole circle of each meridian in turn. In the other an appropriate method has yet to be devised. It is to treat in some general way, as part of the great system of the North Atlantic, the fluctuations of pressure on our north-western coasts. At present it is the practice to regard them as portions of systems which are analogous to tropical revolving storms, or at least of detached cyclonic systems which occasionally cross our islands, and of which the great storm of the Crimea was in a sense the prototype. But this application of the principle of *ex pede Herculem* has so many limitations that some other way of dealing with the phenomena is urgently needed.

"The possibilities of success on the lines of the principles which I have indicated are by no means exhausted; as regards the last example they cannot be said to be even begun. I recall them now because, as each day passes, the force of one or other of them is brought home to me in some practical fashion, and continually reminds me of the services which the award of the Symons Medal commemorates."

Green Flash.

The explanation of the "green flash," seen when the red edge of the sun disappears below the horizon at sunset, or reappears above it at sunrise, namely, that this "green flash" is the apparent image or spectrum of the red edge of the sun seen in the complimentary green colour, is so simple that no further explanation of it seems to be necessary.]

This phenomenon may be illustrated by the following very easy experiment, the account of which is taken, with a few alterations, from Eastlake's translation of Goethe's *Outline of a Theory of Colours*, § 49 :—

"Let a small piece of bright red paper be held before a moderately lighted white surface; let the observer look steadfastly at the small piece of coloured paper, and let it be taken away after a time, while his eyes remain unmoved; a green spectrum will then be visible on the white surface. The coloured paper may also be left in its place, while the eye is directed to another part of the white surface, the same coloured appearance will be visible there too, for it arises from an image which now belongs to the eye."—R. C. Cann Lippincott, Over Court, Almondsbury, Bristol, March 24, 1906.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 17, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

Rev. IRVINE KEMPT ANDERSON, The Rectory, Marytavy, Devon;
Sir HUGH BELL, Bart., Rounton Grange, Northallerton;
Capt. FREDERICK COODE, The Grange, Ward End, Birmingham;
CHARLES HENRY GOTT, Assoc.M.Inst.C.E., 8 Charles Street, Bradford;
CHARLES HENRY GRANT, 212 Burley Road, Leeds;
MELVILLE WILLIAM HILTON-SIMPSON, F.R.G.S., Sole Street House, Faversham;
H. KARL W. KUMM, Ph.D., F.R.G.S., Mount View, Castleton, Sheffield;
ALFRED TAGGART MILLROY, 1 Enid Street, Liverpool; and
MAUNG THAKADO, Prome, Lower Burma,
were balloted for and elected Fellows of the Society.

Rev. JOSÉ ALGUÉ, S.J., Weather Bureau, Manila, Philippine Islands;
Dr. JOHANN GEORG GUSTAV HELLMANN, Kon. Preuss. Met. Institut, Berlin;
Dr. JOSEF MARIA PERNTER, K. K. Central Anstalt für Meteorologie, Vienna,
were balloted for and elected Honorary Members of the Society.

January 17, 1906.

Annual General Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

Capt. M. H. CLARKE and Mr. W. B. TRIPP were appointed Scrutineers of the Ballot for Officers and Council.

The Report of the Council having been taken as read, it was proposed by the PRESIDENT, seconded by Mr. F. C. BAYARD, and resolved: "That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*." [The Report will be printed in the next issue.]]

It was proposed by Mr. A. BREWIN, seconded by Mr. F. J. BRODIE, and resolved: "That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year, and also to the Auditors."

It was proposed by Dr. C. T. WILLIAMS, seconded by Mr. F. DRUCE, and resolved: "That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The PRESIDENT having read the Minute of Council awarding the Symons Gold Medal to Lieut.-Gen. Sir RICHARD STRACHEY, K.C.S.I., F.R.S., in consideration of his eminent services to the science of Meteorology, presented the Medal to Dr. W. N. SHAW, who was present to receive the same on behalf of Sir RICHARD STRACHEY (p. 156).

The PRESIDENT then delivered an Address on "METEOROLOGY IN DAILY LIFE" (p. 81).

It was proposed by Mr. R. INWARDS, seconded by Mr. J. HOPKINSON, and resolved: "That the thanks of the Society be given to Mr. RICHARD BENTLEY for his services as President, and for his Address, and that he be requested to allow the Address to be printed in the *Quarterly Journal*."

The Scrutineers then declared the following to be the Officers and Council for the ensuing year:—

PRESIDENT.

RICHARD BENTLEY, F.S.A., F.L.S., F.R.G.S.

VICE-PRESIDENTS.

Capt. WARREN FREDERICK CABORNE, C.B., F.R.G.S., F.R.A.S.
FRANCIS DRUCE, M.A., F.R.G.S.
Sir JOHN WILLIAM MOORE, M.D., F.R.C.P.I.
Capt. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

TREASURER.

CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E., F.R.G.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., D.Sc., F.R.S.

COUNCIL.

JAMES EDMUND CLARK, B.A., B.Sc., F.G.S.
RICHARD HENRY CURTIS.
WILLIAM HENRY DINES, B.A., F.R.S.
WILLIAM ELLIS, F.R.S., F.R.A.S.
Capt. MELVILLE WILLIS CAMPBELL HEPWORTH, C B., F.R.A.S.
JOHN HOPKINSON, Assoc.Inst.C.E., F.R.M.S.
RICHARD INWARDS, F.R.A.S.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
EDWARD MAWLEY, F.R.H.S.
HENRY MELLISH, D.L., J.P., F.R.G.S.
WILLIAM NAPIER SHAW, M.A., D.Sc., F.R.S.
CHARLES THOMSON REES WILSON, M.A., F.R.S.

February 21, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

CHARLES AUGUST CHEYNE, Heilbrom, Orange River Colony;
OTTO FULTON, African House, High Road, Chiswick;
Lt.-Col. GEORGE MICHAEL JAMES GILES, M.B., 56 Queen's Gardens, W.;
ALFRED JOHN VICTOR RAPKIN, 46 Hatton Garden, E.C.;
WILLIAM HENRY TAYLOR, Cape Town, Cape Colony; and
JAMES WILLIAM WHITE, Royal Engineers' Offices, Hong Kong,
were balloted for and elected Fellows of the Society.

The following communications were read :—

(1) "Report on the Phenological Observations for 1905." By Edward Mawley, F.R.H.S. (p. 113).

(2) "Discussion of the General Features of the Pressure and Wind Conditions over the Trades-Monsoon Area." By W. L. Dallas (p. 141).

(3) "The Dispersal or Prevention of Fogs." By William B. Newton, Ph.D., F.C.S. (p. 151).

CORRESPONDENCE AND NOTES.

Lectures on Meteorology.

During the last three months Mr. William Marriott has given Lectures on meteorological subjects, in connection with the Society's scheme for diffusing a knowledge of Meteorology, at the following places :—

January 16.—Sidcup Literary and Scientific Society.
,, 23.—Exeter Hall, Young Men's Christian Association.
,, 24.—Epsom Literary and Scientific Society.
February 2.—Harpenden Social Union.
,, 8.—Reading Natural History Society.
,, 9.—Bishop Stortford College.
,, 10.—Woolwich, Royal Arsenal Co-operative Institute.
,, 14.—Felsted School.
,, 23.—Chelmsford, Market-day Lecture.
,, 24.—Colchester, Market-day Lecture.
,, 28.—Nantwich Lectures Committee.
March 2.—Derby, Municipal Technical College.
,, 14.—Doncaster Scientific Society.

The Temperature of Cyclones and Anticyclones. By J. Hann. [Translated from the *Meteorologische Zeitschrift*, November 1905, by Dr. R. H. Scott, F.R.S.]

Mr. Helm Clayton has published in part iii. of the *Beiträgen zur Physik der freien Atmosphäre* an article under the title "Various Researches on the Temperature in Cyclones and Anticyclones in Temperate Latitudes," which is of special interest because it, in the first place, throws some light on the reasons which have induced the American meteorologists to arrive at results which differ from those of European meteorologists.

In America it is well known that the higher temperature found in Europe (in the lower strata, up to 5-6 km. (3-4 miles)) in the anticyclones, as compared with the cyclones (in the winter half-year), is not admitted. This appears more strange, because the observations of temperature from Pike's Peak (and particularly from Mount Washington) give the same results as those from European mountain stations.

The paper I cite gives a very full and perfectly impartial summary of all papers on the subject, from mine in the *Zeitschrift*, May 1876 (vol. x. p. 129), down to the latest publications. The general result is given finally as follows :—

"From the foregoing it is to be seen that the investigations of Hann, Dechevrens, Berson, and Teisserenc de Bort, have led to the conclusion that the cyclones are colder than the anticyclones below 9 km. (5½ miles),[1] while the

[1] This limit is rather too high.—Editors.

nvestigations of Harrington, Hazen, Rotch, Shaw and Dines,[1] and myself have shown that the cyclones are on the average warmer than the anticyclones.

"These results, accordingly, appear to be in direct contradiction to each other. If we compare the results of these two groups of investigations a difference comes out very clearly. The investigators have found the temperature in the cyclones colder than the anticyclones in relation to the pressure without taking the time into account, while those who have found the cyclones warmer have taken the temperature in regard of the time of the maxima and minima (except Rotch). Why these two methods lead to different results is not easy to see.

"In order to see if the data of Teisserenc de Bort lead to similar results, if the relation between temperature and pressure is considered with reference to time, I have studied these data according to my method."

Mr. Clayton now takes from the hourly values of pressure at Parc St. Maur, which are published in the *Annales du Bureau Centrdl Mét.*, the times of maxima and minima of pressure between January 27 and March 1, 1901 (waves of pressure of 4 mm. (0·158 ins.) have not been taken into account), and places them in relation to their corresponding temperatures at greater heights in the atmosphere, which Teisserenc de Bort has published in the form of diagrams.

Time of Max.	Feb. 1, 10 a.m.	10, 11 a.m.	15, 12 noon	18, 10 p.m.	21, 11 a.m.
Pressure mm.	754·5	770·3	772·8	766·7	764·8
,, ins.	29·705	30·327	30·402	30·186	30·111

Time of Min.	Jan. 31, 6 a.m.	Feb. 5, 7 a.m.	12, 4 p.m.	17, 3 p.m.	27, 4 p.m.	Mar. 1, 2 p.m.
Pressure mm.	745·3	736·8	762·2	759·2	747·9	742·3
,, ins.	29·343	29·008	30·008	29·890	29·445	29·225

This gives temperature over Paris at the times of maximum and minimum of pressure (only the mean results are reproduced).

Altitude						
	kilometers	0	2	4	6	8
	miles	0	1·2	2·5	3·7	5·0
Maxima	C.	−2°·0	−13°·2	−22°·2	−34°·8	−49°·2
	F.	28·4	8·2	− 8·0	−30·6	−56·6
Minima	C.	1·8	−8·8	−19·2	−32·9	−47·7
	F.	35·2	−16·2	− 2·6	−27·2	−53·9
Difference between Min. and Max.	C.	3·8	4·4	3·0	1·9	1·5
	F.	6·8	8·0	5·4	3·4	2·7

Accordingly the opposite of what Teisserenc de Bort has given.

So far for Mr. Clayton.

[1] The results of the kite observations *only in summer* up to 3 km. (2 miles) on the west coast of Scotland cannot be compared with these. They gave, moreover, by bad stormy weather (in August and September 1903) a more rapid decrease of temperature than by the better weather in summer in the year before. On the other hand, Dines gives the following figures from a kite ascent on January 28, 1905, during an anticyclone in England at the level of 787 mm. (30·985 ins.):—

	..	974 m. (3200 ft.)	1072 m. (3520 ft.)	1170 m. (3840 ft.)	..
Earth .	3·40 p.m.	——	——	4·28 p.m.	4·45 p.m.
	8°·3 C. (47°·0 F.)	4°·4 C. (40°·0 F.)	11°·7 C. (53°·1 F.)	12°·2 C. (54°·0 F.)	7°·2 F. (45°·0 F.)

There is no humidity curve, but there are signs that the air was very dry at the time of change of temperature. The wind below was West, but veered gradually to North-west at the summit without any sudden change (*Nature*, February 16, 1905).

In the kite ascent, August 9, 1904, in an anticyclone over the Atlantic Ocean, the mean temperature of the air column up to 2 km. (1·2 mile) was 22°·1 C. (71°·8 F.). A mass of saturated and damp ascending air, with an initial temperature of 26° C. (78°·8 F.), would in the most favourable case have only 21°·5 C. (70°·7 F.), but if it was 23° C. (73°·4 F.) below, as it really existed, would have only 18°·8 C. (65°·8 F.). The column in the cyclone was therefore about 3° C. (5°·4 F.) cooler. At 4500 m. (14,760 ft.) the observed temperature was 5°·6 C. (42°·1 F.). The cyclone had only 3°·5 C. (38°· 3 F.).

We must first observe that the method in which Mr. Clayton has investigated the temperature in the barometrical maxima and minima has surprised me. We generally understand in dynamical meteorology that barometrical maxima and minima, not the wave heights or troughs of the pressure variation at a definite spot, but the areas (at least on a great scale), decrease all round (maxima) or increase all round (minima).

For these areas, which are the centres of air circulation in opposite directions, Teisserenc de Bort and I have investigated the vertical distribution of temperature in order to get some contribution toward the explanation of their nature. We have taken the daily weather charts for this, and not the barograms of one single place. The vertical distribution of temperature at one spot at the times at which either a maximum or minimum of a wave passes by has not clearly definable physical meaning. The pressure, *e.g.* during a maximum, may decrease and increase again without the maximum losing its character as a centre of diverging (descending) pressure movement, but by the former method there would be a minimum. It is very important to see if the wave hollow at a definite point arises from a real barometrical minimum passing either to the south, north, west, or east. By the method above, these would all be thrown together.

The method which I employed in 1890 (the barometer maximum of November 1889) and later, and which has also been used by Teisserenc de Bort, in order to explain the thermal nature of the barometrical maxima and minima, as they are generally accepted in dynamical meteorology, is certainly unexceptionable, and leads at once to the object of throwing some light on the origin of these atmospherical phenomena.

This method has led to the result (the observations on mountains and those from balloons in free air agree perfectly with each other) that, at least in the winter half-year, the air (as I first said in April 1890) of the cyclones is distinctly cooler than that of the anticyclones.[1] We will not deny that (especially in summer) there may not be (smaller) cyclonic whirls which are relatively warm, as the thermal nature of the actual tropical cyclones is undetermined as yet. It would be a mistake to seek to bring all atmospherical whirls to the same origin.

As it has been determined by observations that, in general, the cyclones are accompanied by dull weather and precipitation, and, on the other hand, the anticyclones by dry, calm weather (excepting ground fogs), this would be a further proof that in the cyclones we have ascending, in the anticyclones descending, motions before us. Now the theory is that ascending damp air masses (when vapour is condensed) cool more rapidly than descending ones get warm. In the vertical circulation which may arise between cyclonic and anticyclonic areas, the rising branch should be cooler than the descending one, which warms itself more rapidly (analogy with the vertical distribution of

[1] We wish to say that we have already placed to the credit of M. Dechevrens (*Zeitschrift*, 1888, p. 7), *that when the barometer is low the temperature on mountain tops is colder than when it is high*, but we have not come to accede to it. M. Dechevrens has not calculated the temperature on the mountain top during a *barometer minimum at the earth's surface*, but at *low barometer on the summit*, which is quite a different thing, for the barometer level on the mountain is a function of the temperature, and on the higher summits the pressure must fall when the temperature of the air column sinks. You do not then get any new result if you group together the temperatures on the summits with the pressure there, but only the confirmation of a well-known physical law which reads—

$$db = \frac{bh}{RT^2} dt.$$

On Pike's Peak the barometer falls nearly 1 mm. (·04 in.) when the temperature falls about 1° C. (1°·8 F.).

temperature on the weather and lee sides of a mountain when a damp air current comes over it).

The results of observation on the distribution of temperature in the cyclones and anticyclones may, therefore, be considered as a fair agreement between theory and experience, and have, therefore, gained a physical importance.[1]

These results were certainly at variance with the generally accepted convection theory of cyclones; a purely thermal (locally thermal) origin of cyclones was contradicted by it, as far as one could not dispute its truth.[2]

Meanwhile, the bottom has been knocked out of the convection theory of extra-tropical cyclones. Ferrel's cyclone assumes a symmetrical distribution of temperature round the centre. I have already shown from the Sonnblick observations that the mean temperature of a column of air of 3 km. (1·9 miles) altitude is much lower on the western side of a barometer depression than on its eastern side; since that the balloon observations have confirmed this result, and shown it more clearly and to much greater advantage. M. Teisserenc de Bort has determined the vertical distribution of temperature in the vicinity of barometrical maxima and minima. Some of the chief results of his energies are :—

MEAN TEMPERATURE IN WINTER AND SPRING IN THE VARIOUS STRATA NEAR LOW PRESSURE AND HIGH PRESSURE AREAS.

LOW PRESSURE.

Region of the	S.E.	S.W.	N.W.	N.E.	Difference.
Ground – 2½ km. 0 – 1·7 miles	– 0°5 C. 31°1 F.	1°9 C. 35°4 F.	– 4°8 C. 23°4 F.	– 1°1 C. 30°9 F.	6°7 C. 12°0 F.
2½ – 5 ,, 1·7 – 3·1 ,,	– 11·7 ,, 10·9 ,,	– 11·8 ,, 10·8 ,,	– 17·1 ,, 1·2 ,,	– 14·6 ,, 5·7 ,,	5·3 ,, 9·5 ,,
5 – 7½ ,, 3·1 – 4·7 ,,	– 25·6 ,, – 14·1 ,,	– 25·5 ,, – 13·9 ,,	– 33·7 ,, – 28·7 ,,	– 30·0 ,, – 22·0 ,,	8·2 ,, 14·8 ,,
Mean	– 12·6 ,, 9·3 ,,	– 11·8 ,, 10·8 ,,	– 18·5 ,, – 1·3 ,,	– 15·2 ,, 4·6 ,,	6·7 ,, 12·0 ,,

HIGH PRESSURE.

Region of the	S.E.	S.W.	N.W.	N.E.	Difference.
Ground 2½ km. 0 – 1·7 miles	1°2 C. 34°2 F.	0°8 C. 33°4 F.	1°2 C. 34°2 F.	– 1°0 C. 30°2 F.	2°2 C. 4°0 F.
2½ 5 ,, 1·7 – 3·1 ,,	– 10·9 ,, 12·4 ,,	– 9·7 ,, 14·5 ,,	– 10·1 ,, 13·8 ,,	– 10·6 ,, 12·9 ,,	1·2 ,, 2·2 ,,
5 – 7½ ,, 3·1 – 4·7 ,,	– 26·7 ,, – 16·1 ,,	– 24·5 ,, – 12·1 ,,	– 19·6 ,, – 3·3 ,,	– 26·1 ,, – 15·0 ,,	7·1 ,, 12·8 ,,
Mean	– 12·1 ,, 10·2 ,,	– 11·1 ,, 12·0 ,,	– 9·5 ,, 14·9 ,,	– 12·6 ,, 9·3 ,,	3·5 ,, 6·3 ,,

[1] See *Meteorologische Zeitschrift*, 1890, p. 226, and 1891, p. 368. Ekholm, "Über Anwendung des Carnotschen Salzes auf die Kreisläufe in der Atmosphäre."

[2] Hann. "Studien über die Luftdruck und Temperaturverhältnisse auf dem Sonnblickgipfel nebst Bemerkungen über deren Bedeutung für die Theorie der Cyklonen und Anticyklonen," *Sitzgsber. d. Wiener Akad.*, April 1891; *Meteorologische Zeitschrift*, 1891, Litb., p. 65. Faye: "Sur les observatoires de montagne au point de vue des cyclones," *Comptes rendus*, 1904, i. p. 835.

The temperature difference of a layer of air 7½ km. (4·7 miles) thick between the extreme quadrants means about 7° C. (12°·6 F.) in a barometer depression. In the anticyclones the temperature is more uniform in distribution.

The inquiry as to the mean temperature of a cyclone or anticyclone has in great measure lost its importance. I would no longer speak of the mass of air of a cyclone, as that would give these phenomena a separate entity. This would be much more applicable to an anticyclone.

The extremes of temperature do not lie at the centres of the cyclones and anticyclones, but rather at their edges. The rear of a cyclone is cold, its front warm. Ferrel's cyclones do not exist, at least in extra-tropical latitudes.

That we have already accepted Teisserenc de Bort's results as to the temperature in cyclones and anticyclones is shown by the latest investigations of Grenander in Sweden, who has worked up the kite ascents at Berlin and Hald (Jutland) in this way.[1]

DECREASE OF TEMPERATURE WITH HEIGHT IN THE BAROMETRICAL MINIMA AND MAXIMA ACCORDING TO QUADRANTS.

I. MINIMUM.

		E.		S.		W.		N.		Mean.	
Km.	Miles.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
0–1	0–0·6	3°·7	6°·7	6°·1	11°·0	6°·5	11°·7	5°·5	9°·9	5°·45	9°·8
1–2	0·6–1·2	5·1	9·2	5·3	9·5	6·0	10·8	4·2	7·6	5·15	9·3
2–3	1·2–1·9	5·2	9·4	5·9	10·6	7·5	13·5	4·6	8·3	5.80	10·4
Total . .		14·0	25·3	17·3	31·1	20·0	36·0	14·3	25·8	16·40	29·5

II. MAXIMUM.

0–1	0–0·6	5·1	9·2	3·4	6·1	1·0	1·8	4·5	8·1	3·50	6·3
1–2	0·6–1·2	5·0	9·0	2·8	5·0	2·5	4·5	3·0	5·4	3·32	6·0
2–3	1·2–1·9	4·4	7·9	3·2	5·8	3·9	7·0	4·8	8·6	4·08	7·3
Total . .		14·5	26·1	9·4	16·9	7·4	13·3	12·3	22·1	10·90	19·6

In the barometer minima the temperature in the west quadrant up to 3 km. (1·9 mile) falls some 20° C. (36° F.), but in the east quadrant only 14° C. (25°·2 F.), as the east quadrant is warmer at its base than the west, so the difference in 3 km. (1·9 mile) is very considerable. In the barometric maximum in the west quadrant (the rear) the temperature decreases 7°·4 C. (13°·3 F.) up to 3 km. (1·9 mile), in the east quadrant 14°·5 C. (26°·1 F.). The average fall appears, from kite observations, in the minima 16°·4 C. (29°·5 F.), in the maxima only 10°·9 C. (19°·6 F.).

As the barometer minima and maxima travel so quickly across the United States, similar investigations are more difficult there. The difference of temperature between the two sides must be much greater in the States than in Europe.

Mr. Helm Clayton quotes the results of M. Dechevrens in regard to the temperature on mountain summits (Puy de Dome, Pic du Midi, Pike's Peak). M. Dechevrens has grouped the temperatures according to the pressure at the mountain tops, by which we get a result which does not agree with what we understand by barometrical maxima and minima in dynamical meteorology. The pressure on mountains falls with falling temperatures and rises with rising temperatures. The low temperature on Pike's Peak with low pressure is therefore in part itself a temperature effect, and the more so the higher the mountain. At Pike's Peak the pressure changes about 1 mm. (·004 in.) for every degree Cent.

[1] "Les gradients verticaux de la Température dans les Minima et les Maxima barométriques," *K. Wet. Akad. Arker.*, 1905. Also Hildebrandsson: "Rapport sur les observations internationales des Nuages," II., Upsala, 1905.

(1°·8 F.) of change of temperature. A low temperature must therefore be connected with low barometer above.[1]

It is more correct when we put to certain barometer readings at sea-level the corresponding layers above and below. This gives no pure physical result, for the same barometer reading may be produced by a system of converging currents (cyclone), or otherwise by a system of diverging currents (anticyclone) above one centre. This must not be overlooked. The answer to the question, With what temperature is high or low pressure to be connected? has a meteorological interest, and then there is the further question, What temperature rules at that time at the summit?

These two questions I have sought to answer by the observations of the years 1886-87. Some results may here be given :—

CORRESPONDING TEMPERATURES AT THE FOOT AND SUMMITS OF MOUNTAINS WITH DIFFERENT BAROMETER READINGS AT SEA-LEVEL. WINTER 1886-87.

Pressure at Sea-Level	mm.	741–55		756–60		761–65		766–70		771–80	
	ins.	29·17–29·72		29·76–29·92		29·96–30·12		30·16–30·32		30·36–30·70	
		C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
Ischl . .		− 2°·8	27°·0	− 1°·5	29°·3	− 4°·5	23°·9	− 5°·9	21°·4	− 6°·5	20°·3
Zell am See		− 4·2	24·4	− 5·5	22·1	− 7·1	19·2	− 10·4	13·3	− 12·3	9·9
Sonnblick .		− 13·2	8·2	− 13·5	7·7	− 17·4	0·7	− 15·1	4·8	− 12·3	9·9
Laibach .		0·9	33·6	− 0·4	31·3	− 5·5	22·1	− 4·5	23·9	− 8·9	16·0
Obir . .		− 6·3	20·7	− 7·0	19·4	− 11·4	11·5	− 8·7	16·3	− 7·5	18·5

With barometer readings below 760 mm. (29·922 ins.) at the earth's surface the mean temperature (Ischl, Yellow Sea) is − 2°·2 C. (28°·0 F.). At barometer readings above 760 it is − 5°·6 C. (21°·9 F.). On the south side of the Alps at Laibach it is + 0°·2 C. (32°·4 F.) and − 6°·3 C. (20°·7 F.). M. Dechevrens has carried out a similar calculation for Clermont at the foot of Puy de Dome, starting from the pressure there. With readings below 724 mm. (28·50 ins.) (local), the temperature was 1°·3 C. (34°·3 F.); above 724 mm. (28·50 ins.) it was − 4°·3 C. (24°·3 F.). As Mr. Dines has remarked, it is wrong to assume that the barometer maxima at the earth's surface are cold on the whole, it does not seem superfluous to quote these data here which might otherwise seem self-evident. As the centre of anticyclones usually comes to lie in the east of England, which gives England South winds, high pressure in England cannot be so seldom accompanied by high temperature.

On the Sonnblick in the winter 1886-87, although there were many changes of temperature, the temperature with mean pressure was lowest; yet Zell am See was as cold as the Sonnblick, although there was 2400 m. (7875 ft.) difference of level. Laibach was colder than the Obir with about 1700 m. (5578 ft.) difference of level.[2]

Rainfall at Nugawella and Weliganga, Ceylon, 1904-5.

Mr. A. J. Wilmshurst has favoured us with the daily amounts of rainfall at Nugawella and Weliganga Tea Estates, Ceylon, for the years 1904 and 1905. These places are in lat. 7° 4′ N., and long. 88° 33′ E. At Nugawella, which is 2000 ft. above sea-level, the rain-gauge is 4 ft. 2 ins. above the ground; and

[1] I have shown no opposition to Loomis, who has not considered this question (*Zeitschrift*, 1879, p. 154). It is therefore not right when we take Helm Clayton's article. Hazen endeavours (*American Met. Journ.*, vol. iv. p. 263) to explain the results of Dechevrens and Hann by the circumstance that the low temperature at the back of the summit contracts and so produces a low temperature above. I have not overlooked this fact.

[2] Hann. "Über die Beziehungen zwischen Luftdruck und Temperaturvariationen auf Berggipfeln," *Meteorologische Zeitschrift*, 1888, p. 7.

at Weliganga, which is 1846 ft. above sea-level, the gauge is 4 ft. above the ground.

The monthly amounts were as follows :—

Months.	Nugawella.						Weliganga.					
	1904.			1905.			1904.			1905.		
	Total.	Greatest in One Day.	No. of Rainy Days.	Total.	Greatest in One Day.	No. of Rainy Days.	Total.	Greatest in One Day.	No. of Rainy Days.	Total.	Greatest in One Day.	No. of Rainy Days.
	in.	in.		in.	in.		in.	in.		in.	in.	
January . .	8·92	2·30	15	1·68	·92	6	9·88	2·47	12	0·80	·55	2
February . .	0·29	·19	3	4·38	1·95	6	0·14	·14	1	5·76	2·35	9
March . . .	2·25	·93	6	4·73	1·13	8	2·37	·71	7	5·87	2·82	6
April . . .	2·60	·78	15	12·88	3·40	14	6·12	1·27	15	15·03	3·43	17
May . . .	21·69	6·03	22	20·42	5·45	22	25·54	5·10	22	17·21	4·25	27
June . . .	47·06	6·34	30	22·65	2·80	21	28·39	2·63	29	16·62	2·60	21
July . . .	20·20	2·10	30	13·84	3·02	17	16·68	2·11	25	7·69	1·27	18
August . .	6·83	1·15	17	8·67	1·47	14	5·58	1·00	12	10·20	2·27	17
September .	20·71	2·47	25	12·62	2·58	11	17·73	2·83	19	10·63	2·66	19
October . .	13·80	1·83	29	21·53	3·08	19	19·48	2·75	23	19·03	3·35	20
November .	11·35	2·58	16	11·75	2·12	16	9·31	2·25	14	10·75	2·90	15
December .	7·06	2·53	14	3·24	1·30	5	7·24	2·75	8	1·80	·75	5
Year . .	163·76	6·34	222	138·39	5·45	159	148·46	5·10	187	121·39	4·25	176

Relation of Temperature on the Ground to Humidity.

Noticing, in the observations made at the Royal Observatory, Greenwich, the agreement occasionally between the readings of the solar and the maximum, also between the grass and minimum, thermometers, the following were recorded :—

Date.	Solar.	Max.	Date.	Grass.	Min.
	°	°		°	°
1887. Dec. 18 . .	45·1	45·6	1887. Dec. 23 . .	23·3	23·4
1888. Jan. 5 . .	52·2	52·2	1888. Jan. 16 . .	34·0	34·2
,, ,, 29 . .	46·8	46·8	,, ,, 17 . .	30·0	30·0
			,, ,, 29 . .	37·1	37·3

During the rest of the year there were several more agreements between the grass and the minimum thermometers, which, however, need not be brought forward.

The solar and the grass thermometers are both exposed on the ground ; the maximum and the minimum thermometers are in shade at 4 feet 6 inches above the ground.

Continuing to note these coincidences, curiosity was excited to ascertain what they implied. Not to offer too many examples, those for the year 1905 only will be exhibited :—

1905.	Solar.	Max.	1905.	Grass.	Min.
	°	°		°	°
Jan. 19 .	37·5	37·5	Jan. 23 .	32·0	32·5
,, 22 .	37·0	36·0	Feb. 2 .	38·1	38·5
Feb. 23 .	37·0	36·2	,, 24 .	33·8	34·4
Oct. 4 .	52·5	52·5	Apr. 4 .	36·7	36·7
Dec. 4 .	38·6	35·8	May 20 .	51·0	51·1
,, 10 .	38·7	38·7	June 6 .	46·8	46·8
,, 14 .	38·5	38·5	,, 7 .	46·0	46·1
,, 15 .	43·7	44·0	Aug. 29 .	52·6	52·6
,, 17 .	42·2	42·2	Sept. 25 .	49·0	49·7
,, 22 .	47·9	47·5	Dec. 1 .	39·0	39·6

The coincidences were related to overcast weather with either mist, fog, rain, or snow, and the stratum of air, 4 feet 6 inches, was saturated with vapour, or nearly so—indicating a relation of the temperature of the ground to humidity.

RANGE OF TEMPERATURE ON THE GROUND AND RELATIVE HUMIDITY, 1893-4.

April.			May.			June.			July.		
°	%	obs.	°	%	obs.	°	%	obs.	°	%	obs.
94·5	53·2	4	101·0	55·0	2	99·3	51·5	4	93·3	57·3	3
85·1	60·0	10	94·6	59·8	11	92·4	60·6	7	82·2	66·6	10
75·1	70·0	7	84·5	72·2	7	84·6	66·1	10	73·6	69·7	10
66·6	78·0	4	76·2	67·0	6	77·6	69·0	5	62·4	80·5	2
58·3	76·0	3	63·6	76·8	4	59·0	79·0	2	50·1	86·0	2
29·0	84·0	2	40·5	66·0	1	46·7	79·5	2	42·6	88·2	4

August.			September.			October.			November.		
°	%	obs.	°	%	obs.	°	%	obs.	°	%	obs.
92·3	64·5	2	87·4	67·4	4	74·2	79·5	6	66·7	76·0	2
87·0	65·3	8	81·9	66·5	4	63·1	76·8	5	52·8	78·0	2
83·2	64·1	8	74·1	71·7	7	54·3	77·2	6	43·0	86·0	3
76·7	75·8	6	68·1	73·3	7	44·7	76·0	7	30·2	81·2	4
67·7	71·2	4	56·7	84·3	3	36·8	89·0	3	23·9	85·0	11
56·5	82·3	3	44·5	88·6	5	24·2	89·8	4	13·6	88·0	8

December.			January.			February.			March.		
°	%	obs.	°	%	obs.	°	%	obs.	°	%	obs.
45·2	91·0	1	50·7	79·0	2	62·0	77·2	6	90·0	70·7	4
31·7	84·0	5	43·1	77·7	3	56·2	75·5	2	81·5	77·2	6
26·7	85·0	7	35·5	80·0	7	47·0	80·5	6	69·2	77·6	7
22·3	85·2	12	25·0	80·5	9	32·0	85·0	6	58·8	79·8	8
18·7	87·5	4	16·8	91·0	6	22·9	89·0	4	43·8	85·7	3
11·8	94·0	2	12·2	94·2	4	14·0	92·2	4	30·1	90·7	3

For the Year.		
°	%	obs.
99·9	52·7	6
93·2	60·7	31
84·1	66·6	67
75·6	71·7	47
65·8	76·1	41
56·0	79·5	33
44·5	82·1	35
32·9	84·1	28
24·3	84·9	49
14·7	90·5	28

Mean of Months.	Humidity.	Max. in Sun.	Min. on Grass.	Range on Ground.
	%	°	°	°
April	67·0	109·0	33·9	75·1
May	66·1	121·9	38·5	83·4
June	65·1	126·2	43·2	83·0
July	71·6	120·9	48·9	72·0
August	69·4	126·8	47·9	78·9
September	74·2	109·9	41·1	68·8
October	80·1	91·3	39·4	51·9
November	84·3	59·9	31·2	28·7
December	86·0	53·2	28·8	24·4
January	84·0	57·3	29·8	27·5
February	83·3	71·6	32·0	39·6
March	79·2	96·1	30·8	65·3

The "Degree of Humidity" is deduced from the mean daily temperature of the air and that of the dew-point. It seemed evident that the daily range of temperature on the ground must be related to the humidity. The problem was to trace out and test the general relation. The examination of the observations for an entire year seemed desirable, and the *Weekly Returns* of the Registrar-General being to hand were chosen, with the results in the annexed tabulation.

The temperature indicated by a thermometer exposed on the ground to radiation may be considered to coincide very nearly with the actual tem-

perature of the lowest strata of the air. Taking the register of the solar thermometer as the maximum temperature of this air, and that of the grass thermometer as its minimum temperature, the difference between their indications in the same civil day will be the daily range of surface temperature. As this daily range increases the mean daily percentage of humidity decreases, or the air becomes drier, as a general result; and as the range decreases the humidity increases, or the air becomes damper.—RICHARD STRACHAN, March 17, 1906.

Lightning at Barsham, Suffolk, February 8, 1906.

The Rev. Allan Coates, of Barsham Rectory, near Beccles, sends the following interesting note on the thunderstorm of February 8 :—

Between 2.15 and 2.30 p.m. I was sitting in my study, which faces west, with my back to the window. I had heard some rumbles of thunder, and then a very brilliant flash of lightning caused me to turn round and look out of window. Between this flash and the thunder I counted 12 or 13. In about a minute it began to rain hard, and I saw a very vivid flash of zigzag lightning from west-north-west passing to north, and in the limited field of vision between a tall cedar and a large clump of yew-trees it seemed to be almost horizontal, slightly inclining downwards towards north. The wind was then blowing from North-west, and it began to hail. I counted 5 or 6 only before the thunder came. Then almost immediately, in the north-west, there appeared a huge circle of light, giving the impression of the heavens being opened, most vivid, and in size, as far as one could judge, 2 or 3 times the diameter of a setting sun. It appeared just above the cedar in height, but not near it in distance from me. *At the same moment* an appalling crash came like the bursting of a big shell immediately overhead. This was, I suppose, the moment at which the east end of our church, 100 yards from this house, was wrecked. The circle of light was visible for some appreciable time. The hail turned to snow, and there was no more lightning.

My wife, in a room above this sitting away from the window, describes the appearance almost exactly as I have done, except that she says the colour was very yellow, like gas, whereas I should say it was white or nearly so. My daughter, aged sixteen, looking out of window from the same upstairs room, speaks of it as a huge ball of light like a great sun, and says that the whole garden seemed to be a blaze of light. These two add that the globe of light seemed to travel over the house. If so, it would also pass over the church, and coming from north-west would naturally disappear in south-east, as the gardener says.

My gardener, looking out of the stable door facing south-east, uses the same expression as I have just done, viz., that the heavens seemed opened above him, and two huge arms of yellow light seemed to come together and joining strike the earth to the south-east. This might have been what set on fire the farm at Brampton some 4 miles south-east of this.

RECENT PUBLICATIONS.

Annales du Bureau Central Météorologique de France. Publiées par E. MASCART, Directeur. Année 1902. 3 vols. 4to. Paris, 1905.

Part I., "Mémoires," contains the following papers:—"Thunderstorms in France and the State of the Atmosphere in 1902," by M. Fron.—"Magnetic Observations made at the Observatory of Val Joyeux, 1901," by T. Moureaux.—"Studies on the Climate of France, Temperature, Second Part; Diurnal Variation of Temperature," by A. Angot.—"Seismic Observations made at the Pic-du-Midi Observatory, 1896-1902," by M. Marchand.

Part II. contains the detailed meteorological observations made during the year 1902.

Part III. contains the daily observations of rainfall.

Leitfaden der Wetterkunde. Gemeinverständlich Bearbeitet. Von Dr. R. BÖRNSTEIN. Zweite, Umgearbeitete und Vermehrte Auflage. Braunschweig, 1906. 8vo. 231 pp. and 22 plates.

This guide for weather knowledge has been written so as to be intelligible to ordinary people, and is illustrated by a number of coloured plates.

The author first deals with the constituents of the atmosphere, and then proceeds to treat of the blue sky and the reasons for this. He then refers to the distribution of temperature over the globe, and shows by diagrams the differences of different soils, etc. In all things he brings in the results of the most recent balloon and kite observations. This is followed by an account of the rise and falling of temperature in the föhn air.

He then gives an account of clouds and their formation, with a notice of the different classification of clouds by various authors. This is followed by accounts of weather types, and the book closes with a notice of the weather services in the different countries which have organised it.

Thunder and Lightning. By CAMILLE FLAMMARION. Translated by Walter Mostyn. With Illustrations. London: Chatto and Windus, 1905. 8vo. 281 pp.

The author says that it would be an interesting thing to make a careful study once a year, towards the end of the summer, of the habits and customs of thunder and lightning. Perhaps in this way we should succeed one day in determining the still mysterious nature of these elusive forces. He has been engaged upon the task for many years past. He has consequently accumulated a large number of records, and in this volume he gives a résumé of them.

The book is divided into ten chapters, which are as follows:—1. The Victims of Lightning; 2. Atmospheric Electricity and Storm Clouds; 3. The Flash and the Sound; 4. Fireballs; 5. The Effects of Lightning on Mankind; 6. The Effects of Lightning on Animals; 7. The Effects of Lightning on Trees Plants; 8. Effects of Lightning on Metals, Objects, Houses, etc.; 9. ; and 10. Pictures made by Lightning.

lection of the effects of lightning under all sorts of condi- are very curious and amusing, as will be seen from the

—

57 a peasant woman of Seine-et-Marne, who was minding lightning under a tree. The cow was killed, and the the ground insensible. She was, however, soon revived. s to attend to her, the people who came to her assistance duced on her breast *a picture of the cow.*"

"In the summer of 1865 a doctor from the neighbourhood of Vienna, Dr. Derendinger, was returning home by train. On getting out at the station he found that he had not got his purse on him—some one probably had stolen it.

"This purse was made of tortoise-shell, and had on one side of it a steel plate marked with the doctor's monogram—two D's intermingled.

"Some time after the doctor was called to attend to a stranger who had been found lying insensible under a tree, having been struck by lightning. The first thing that he noticed on examining the man's body was that on his thigh there was a reproduction, as though by photography, of his own monogram. His astonishment may be imagined. He succeeded in reviving the stranger, who was taken to a hospital. The doctor remarked that in his clothes his lost tortoise-shell purse would probably be found. So it proved. The individual struck by lightning was the thief. The electric fluid had been attracted by the steel plate, and had imprinted the monogram upon the man's body."

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

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SOUTH AFRICA AS SEEN BY A METEOROLOGIST DURING THE VISIT OF THE BRITISH ASSOCIATION IN 1905.

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[Abstract of a Lecture delivered before the Royal Meteorological Society, March 21, 1906.]

THIS is not a formal lecture on the Meteorology of South Africa, but merely notes of the impressions made on a mind mainly intent upon the meteorological aspects of things, and illustrated so far as such impressions are capable of illustration by photographs taken at the time. These photographs abound, like most amateur work, in unpleasant surprises, and many of the most interesting features of which views had been obtained with great expectations cannot be produced on the screen at all. This is due chiefly to three causes which the itinerant photographer going to new lands may profitably bear in mind. First, the programme for the trip was extensive and the time was short, so that a snapshot often had to be taken in unfavourable conditions of illumination or the record would be lost, for it was rarely indeed that we had an opportunity of seeing the same view twice. Second, in anticipation of the intensity of tropical sunshine, there was a tendency to give short exposures and to use small stops, forgetting the effect of the prevailing dust-haze of the dry season, which reduced the light so greatly that under-exposure was the most common fault discovered in subsequent development. Third, and worst, the return journey led us through climates of damp heat, which seriously damaged all films not protected by being sealed in air-tight cases; and as my supply of such cases was too small, the photographs have suffered accordingly.

The trip extended to some 19,200 miles, and occupied 82 days—from July 29, when we sailed from Southampton for Cape Town in the *Saxon*, to October 18, when we reached London again, *via* the east coast of Africa, Suez Canal, and Marseilles. The generous provision made by the governments and people of South Africa for the transport and entertain-

ment of the over-sea members of the British Association, the subsidies given by the Association to those officially taking part in its work, and the concessions accorded by the Union Castle Company as regards routes and rates, enabled this long journey to be made in greater comfort and at smaller cost than any of us are likely to have the good fortune to experience again. It thus became a duty for those who were so splendidly received to endeavour to learn something of the regions thrown open to them, and to make known the conclusions they arrived at as widely as possible. My opinions, I hasten to explain, are purely personal; they were largely based on reading and on conversation with travellers during the last fifteen years, greatly modified, though not fundamentally changed, by the six weeks spent in South Africa, and still developing, thanks to the fresh light which the short glimpse of the real places and people continues to throw on the present state of affairs as detailed in the newspapers.

I must confess that my first impressions of the tropics were disappointing. After a day of genial heat at Madeira, amongst palms and flowers, the breath of the North-east Trade struck cool, and even when, on August 4, in 20° N., the sun, rising south of east, passed through the zenith and set north of west, the sea air was not noticeably warm. We had passed from summer to spring, and the season became earlier every day as the shadows lengthened towards the south and the noon-tide sun daily rose less high above the northern horizon. Passing close to Cape Verde, the ship avoided the calm belt of the doldrums, for the North-east wind merely shifted to the North-west for one steamy day, and then turned gradually to South-east, growing again to the full force of the Trades. The equator was crossed early on the morning of the 8th, and the rest of our time in the tropics was cold; waistcoats were resumed within twelve hours of the equator, and on the 12th, when we entered the South temperate zone, topcoats appeared. The wind turned to the West and the big ship began to roll for the first time two days before August 15, when she entered Table Bay at dawn. That day, corresponding in season to February 12 with us, was the coldest of the year, the minimum temperature in Cape Town being only 38°.

The Meteorological Sub-section of the British Association did not meet last year, and the numerous papers which were presented on meteorological subjects were grouped in various sections and received but little attention. I do not know with whom the responsibility lay for this state of matters, but probably less should be laid on the shoulders of the overworked officials of Section A than on the Council of the Association, which nominates the various sectional officers. However it happened, the result was peculiarly unfortunate, for there is no country in the world, and certainly no group of colonies in the Empire, in which a proper presentation of meteorological science would have been more useful or more timely than in South Africa in 1905. It cannot be supposed that the resolution of the Council advocating an imperial meteorological organisation could have much weight when the Association met in two colonies and passed through five others with no visible recognition of the independent status of Meteorology.

Outside the walls of the meeting rooms in Cape Town there was much to see in the beautiful slopes of Table Mountain, glimmering with the young foliage of the silver trees and starred with the first spring flowers,

arum lilies growing in the ditches, and on the other side the lovely valley through which the long line of suburbs runs from Mowbray to Wynberg. There was also the mountain itself, which was visited by numerous parties of scientific excursionists; and fortunately the day selected was fine, for the rainfall on the flat terraces which form the summit of the little plateau is about three times as great as on the plains below. The reservoirs for the supply of Cape Town are situated picturesquely in a valley on the lower plateau, and the clear, coffee-coloured water, the colour due to some soluble vegetable matter, made an effective contrast to the green of the young plantations round them. Only a few days before there had been an excellent example of the mist "tablecloth"; it was in one of the photographs that failed.

FIG. 1.—The 8-inch Rain Gauge at the Royal Observatory, Cape Town.

The Royal Observatory to the north of Cape Town was thrown open to the visitors, and Sir David Gill gave every opportunity for a full inspection of the premises and instruments. The most unusual part of the meteorological equipment was that for the measurement of rain, the standard gauge having a diameter of about 11¼ inches, or exactly such a diameter as gives a surface twice the area of an 8-inch gauge, so that the same glass may be used for both, the half-inch glass for the 8-inch gauge being filled by a quarter of an inch of rain from the larger size. The usual exposure of the rain gauge in Cape Colony is upon a concrete or cement pillar 4 feet high, a fact that must be borne in mind when comparing the readings with those of gauges at the home standard height of 1 foot. Meteorology in Cape Colony suffers by the excessively small annual grant available, which allows very modest office accommodation and inadequate assistance to the Secretary of the Meteorological Commission, Mr. Charles Stewart, whose work in such difficult circumstances is surprisingly efficient. It seems to me that failing the wide scheme of

imperial meteorological co-operation, or as paving the way towards it, the establishment of a central Meteorological Department for Africa south of the Zambesi would result in a great advance both of scientific research and practical applications.

From Cape Town the members of the British Association proceeded to Durban, where the familiar phenomenon of a thunderstorm at a garden party gave a home-like touch to the surroundings. Thence the party proceeded in four special trains, which soon after leaving Durban commenced to ascend the steep sides of the great South African Plateau. Two pleasant days were spent at Pietermaritzburg, and then the journey through Natal northward was resumed by remarkably steep gradients on a singularly serpentinous line. The days grew hotter and the nights

FIG. 2.—Meteorological Observatory, Johannesburg.

colder as we approached the summit of the bordering ranges and stopped for a couple of days at Colenso and Ladysmith. The dry season was at its height: by day the country was an expanse of yellow or blackened grass, by night the light of veldt-fires was frequently to be seen, as the natives burn off the old grass in order to promote the growth of a fresh and tenderer crop. On August 28 we reached Johannesburg in the early morning, and here there was a pause of nearly a week while the second half of the scientific meetings of the Association took place.

From our present point of view there is nothing to be said about gold or Chinese labour. The gold industry makes itself felt to the stranger by the intolerable clouds of dust from the finely crushed tailings, which mask the advantages of a climate otherwise bright and exhilarating. The absence of rain in the dry season aggravates the dust, and were it not for the green of the great groves of eucalyptus trees, planted by the first settlers sixteen years ago, the surroundings on the plain of yellow grass broken by bare and formless hills would be dreary indeed.

The need of this lofty plateau for a water-supply for irrigation is one of the strongest impressions produced by travelling through the country.

The Transvaal Government spends a comparatively large sum of money on meteorological work, and Mr. R. T. A. Innes has an admirably fitted-up little observatory on a site which offers peculiar advantages for anemometer work, though, from its position on the summit of a narrow ridge, it certainly cannot be taken as favourably situated for studying the other climatic elements of the town. Meteorology is perhaps more modest even as regards its sites than the sister science of Astronomy, for the pursuit of which the Johannesburg Observatory would have more obvious advantages. There is, however, a stretch of lower ground available on which a rain gauge and earth-thermometers are already established. The rain gauges of the Transvaal system are supported at a height of 4 feet on iron tripods, and have a diameter of 5 inches as compared with 8 inches in Cape Colony. On the summit of the hill there is a sunshine recorder and an evaporation tank—and at that high altitude, over 5000 feet, with the excessively low humidity that prevails, water is said to be as volatile as alcohol is with us. There is also a large louvred building, a sort of thermometric laboratory in which thermographs may be placed comfortably on tables and their records readily examined while the instruments are at work. In the observatory itself there are recording anemometers and an excellent mercurial barograph. Mr. Innes has made great progress in a short time, and the Transvaal has every reason to be proud of its metropolitan meteorological office.

From Johannesburg we passed southward through the Orange River Colony, and at Bloemfontein I had the pleasure of meeting Mr. Lyle of Grey College, who is in charge of the meteorological system of that colony. He follows the usual South African method of exposing rain gauges at 4 feet, but has an ingenious and economical stand for the 5-inch gauge employed. This is a cylinder of corrugated iron about 1 foot 6 inches or so in diameter, such as can be made by any country blacksmith out of the chief building material of the country. The station at Grey College is not a particularly favourable one; but I accompanied Mr. Lyle in a visit to the new site for the College, to which it is shortly to be moved, and there we fixed upon an excellent position for a meteorological observatory and experimental station. Throughout the Orange River Colony, almost more than in the Transvaal, the vast importance to the country of some means of irrigation was impressed upon one at every turn.

The special trains crossed the Orange River southwards into Cape Colony and were transferred to the line running northward through Kimberley into Rhodesia. Two days were spent in Kimberley, in heat and dust, visiting the diamond mines, and seeing something of the scene of military operations during the late war. Time was found by several members interested in observational studies to visit Mr. J. R. Sutton's house at Kenilworth, the garden suburb maintained by the De Beers Company. Mr. Sutton was recovering from the effects of a serious accident and was unable to show the observatory personally, but Mrs. Sutton, who assists him in his meteorological work, was a very able substitute. The splendid work done at this observatory is too well known to Fellows of this Society and to scientific men in Europe to

require recapitulation. I am by no means sure that it is equally recognised in the colony itself, though in the future its value is bound

FIG. 3.—The Bush Veldt, Rhodesia.

to become apparent. It is to be hoped that steps will be taken to place the Kenilworth Observatory on a permanent footing.

FIG. 4.—A Street in Bulawayo.

Travelling northwards from Kimberley through Bechuanaland, the appearance of the country gradually improved, the grass grew less yellow,

shrubs appeared, and the district of the bush veldt was entered. Everywhere the effects of the dry season remained apparent, and more than once extraordinary clouds, the position of which in any classification would have been extremely troublesome, revealed themselves on a nearer approach to be swarms of locusts. As we approached the borders of Rhodesia the trees were seen to be putting forth their young leaves in anticipation of the wet season still several weeks away.

A short stay was made at Bulawayo, a town of magnificent distances, planned with a boldness that seemed to aim at a future of hundreds of thousands of inhabitants. The intense heat and glare by day, and the vast accumulations of dust in the long, straight streets, too wide for any probable traffic and lined by low buildings, showed one how width and

FIG. 5.—Father Götz at Bulawayo.

straightness, however desirable in the busy towns of the temperate zone, are out of place in the arid zone of the tropics. Comfort and convenience would, I think, be promoted by having narrow, winding streets, smoothly paved and with tall buildings to cast a deep shadow, while the houses might be grouped round internal courtyards with an irrigated garden in the centre to rest the eye with its greenness. The meteorology of Bulawayo is under the charge of Father Götz, one of the Jesuits engaged in educational work. He was trained in the Weather Bureau at Washington, and is keen and enthusiastic in his observations. The instruments in his garden include an extremely ingenious electrical recording rain gauge constructed by himself and apparently very efficient. On the day I was there the dry-bulb thermometer was reading 85°, the wet-bulb 55°, indicating an excessively low relative humidity.

A trip was made to the Matopo Hills—bare, rounded, granite kopjes weathered in concentric layers like the coats of an onion, often with rounded boulders resting on their summits and slopes. Around the

base of these hills the vegetation is comparatively luxuriant, and a great stretch of country is railed off as a natural zoological garden in the

FIG. 6.—Early morning on the Rhodesian Plateau (scene at Railway Station).

Rhodes Memorial Park. The most impressive feature in a wonderfully impressive region is the simple grave of Cecil Rhodes, the creator of

FIG. 7.—Afternoon on the Rhodesian Plateau (scene at the Railway Station).

Rhodesia, whose genius is stamped on the face of the whole great possession. It lies on the summit of a bare granite hill commanding "the view of

the world," a magnificent expanse of hill and wood, the grandeur of which, as we saw it, was marred only by the absence of solitude, for the party was large.

FIG. 8.—The Victoria Falls from Livingstone Island.

FIG. 9.—The Chasm of the Victoria Falls.

From Bulawayo we proceeded in great extremes of heat by day and cold by night over the gradually sinking plateau covered with increasingly abundant forest to the Zambesi river, and on the morning of

September 12 we awoke in the train with the sound of "the thundering smoke" in our ears. The one disappointment of the whole expedition was the short time allowed in the programme for the visit to the Victoria Falls; but the intense heat of a truly tropical day did not deter any of the party from utilising every minute of the time. It is impossible by description or even by photographs to do justice to the Falls. Statistics afford some relief in the effort to convey an idea of the scene, but even they leave a feeling of absolute inadequacy behind. The river Zambesi immediately above the Falls is rather more than a mile wide and flows on the general level of the country, the banks rising only a few feet above the water. The current is not rapid in the dry season, and canoes can ply between the islands a few hundred yards above the chasm.

FIG. 10.—Meteorological Observatory, Beira.

This vast placid river precipitates itself, along its whole breadth, save where the islands come to the edge, into a chasm 400 feet deep and less than 100 yards wide, from which the only escape for the pent-up water is through a narrow gorge, now spanned by the "Cape to Cairo" railway, and thence by a zig-zag canyon cut deep in the black basaltic rock. The river varies greatly in volume with the season; when I was there it was near the end of the annual dry season and the water was at its lowest. The Falls consequently lost much of their grandeur, but, on the other hand, the comparative absence of spray made it possible to see into the depths of the chasm and gorges, and the low water rendered several view-points accessible which could not be approached during the rains. The coolness of the nights was a feature as marked as the heat of the unclouded days, and almost more unpleasant.

Returning to Bulawayo, the British Association party broke up into two divisions, one going back direct to Cape Town for the west coast steamer, the other, which I had the privilege of accompanying, proceed-

ing by Salisbury and Umtali to the port of Beira in Portuguese East Africa, and thence by a special steamer of the Union Castle Line along the east coast and through the Suez Canal. The eastern portions of Southern Rhodesia formed by far the most inviting country seen north of Cape Colony; it looked like a land made for cattle-rearing, and some of the residents whom I saw were confident that once a remedy or preventive is found for the scourge of cattle disease, which a few years ago devastated the country, it will become highly prosperous once more. The mineral resources of this colony, considerable although these undoubtedly are, do not overshadow all other sources of well-being to the extent they do in the neighbourhoods of Johannesburg and Kimberley, and the natural assets of soil and climate are not likely to be ignored.

FIG. 11.—First-class Carriages on the Uganda Railway.

There is an excellent second-order meteorological station at the Hospital in Salisbury, and observations are carried on at Umtali also, though not in the same detail. In Beira the meteorological station is an imposing structure and the rain gauge is of heroic dimensions.

On the homeward voyage the vertical sun was encountered at Mombasa in about 4° S., but the day spent there felt cooler than many a summer afternoon in London, for the sea-breeze was blowing strongly, tossing the palm fronds in the coco-nut groves, and imparting an air of quite unexpected freshness to the quaint old equatorial town. The carriages on the railway which runs from Mombasa to Uganda were interesting in showing adaptation to the peculiar conditions. They are built of metal to defy wood-loving insects, provided with extraordinarily deep ventilators protected by wire-gauze against mosquitoes, and the windows are provided with green-tinted glasses to enable passengers to see the landscape and escape the merciless glare of the sun.

The homeward voyage was characterised by unvarying fine weather,

with remarkably clear skies, allowing the interesting atmospheric phenomenon of the "green flash" at sunset and at sunrise to be seen almost daily. The fortunate circumstance of a block in the Canal occurring just before the *Durham Castle* was due at Suez, enabled us to spend a few unexpected days in Egypt. South Africa had supplied a wearying succession of instances of the drawbacks of an arid climate; Egypt was a magnificent example of the vivifying power of water in a rainless land. In some parts the railway from Ismailia to Cairo runs so closely on the line that separates the waterless desert from the irrigated delta that one

FIG. 12.—The Nile Inundation near Cairo.

side of the train commands a view of boundless yellow sand unrelieved by tree or herb, while the other shows a scene of verdure in which every square foot is bearing a crop. The Nile was still in high flood as we saw it, and the low lands on either side of the main stream were covered with a wide expanse of water, soon to subside and leave the ground fertilised by the new season's deposit of Nile mud carried down by the equatorial rains.

In conclusion, I again have to repudiate any idea of this discourse being a lecture on the climate of Africa, and to explain that it is merely a running comment on pictures and impressions picked up in the course of a very pleasant but very hurried holiday trip.

SOME SO-CALLED VAGARIES OF LIGHTNING REPRODUCED EXPERIMENTALLY.

By ALFRED HANDS, F.R.Met.Soc.

[Read April 18, 1906.]

I TAKE it to be an axiom in meteorology, as in every other branch of natural science, that nature works by law; that there is no effect without a cause, and that given the same causes and conditions in two or more cases the results will be precisely the same.

There should, therefore, be no vagaries, freaks, or eccentricities in any form of nature. Possibly the terms may be permissible if intended only to imply something out of the ordinary, and they are frequently used in this sense in connection with our much-abused British weather, even though the causes that have led to the unseasonable changes may admittedly be known to meteorologists.

These terms are, however, frequently used—I may even say are almost habitually used—in connection with lightning in a way that would lead to the inference that this force, unlike every other one in nature, was erratic; not governed by law, and even prone to act in violation of it.

Now, lightning is an electric discharge; about this there is no possibility of doubt; and as such it should act in accordance with the laws that are known to govern the subject. We have doubtless much to learn yet as regards electricity, but even though fresh facts and laws may be discovered, they can scarcely be in direct opposition to those already known, and, therefore, if an occurrence does not appear to accord with our knowledge, we should try and fathom the mystery and not dismiss it as a vagary.

In the course of an extended investigation into the effects of lightning, I have come across many cases that have been called vagaries, but which on a close inspection have proved to be extraordinary only in the erroneous way in which they were described, and, had they been correctly reported, they would have appeared perfectly consistent with preconceived ideas—in fact, could have been foretold in every case if the conditions that led to those effects had been known before the events occurred.

Some cases are not worth reproducing, because they are natural phenomena correctly reported and appear peculiar to the observers only because of their want of knowledge of the subject. For instance, I remember a case, some dozen years or more ago, described at the time as an extraordinary freak of lightning, in which a house was struck, the flash making a hole in a gas pipe and lighting the gas, which, in turn, set fire to some woodwork; but it also made a hole in a water pipe, in such a way that the water played on the fire and put it out. This was a case in which two soft metal pipes—one a 'compo' gas pipe, the other a lead water pipe—crossed one another closely, so the discharge, having passed through the roof to the water tank and down the rising main, divided, of course, between the two paths of metal available to earth, viz. the gas pipe and the water pipe, fusing a hole in each where the spark passed across, and, while the lighted gas curled upward and charred the wood

above it, the jet of escaping water, impinging on the gas pipe, was sprayed over the wood, keeping it moist and preventing its bursting into flame.

I am not showing this case by experiment, partly because it is so obviously a natural occurrence, but also because I should find great difficulty in making pipes sufficiently thin to be fused by the spark that I find it convenient to use here, and yet strong enough to withstand the pressure of gas and water necessary to show the effects; but I mention it as being a type, and I have selected for reproduction a few cases that may be regarded as typical of other kinds of occurrences, although, since the inconsistency of the reports with the actual facts varies according to the imaginations of those who have wrongly described them, it is obviously difficult to arrange them in classes. The only way one can so divide them is to classify the kinds of occurrences that lead to the erroneous reports.

I have made a few rough models which will serve perhaps to bring the conditions more clearly to mind.

Beginning with the most simple case—one in which something was seen and imagination, aided no doubt by an after-inspection of the effects, led to a description that implied a vagary—I will show an occurrence at a church in Sussex about 1890. I am not sure whether it was at Uckfield or Cuckfield, but it was one of the two. This model is intended to represent the church. Some one was looking at the clock when, so he stated, he saw a flash of lightning strike it obliquely. We will now try an experiment with this model, and if you will watch the clock, as he did, I think you will be able to see what it was that he really witnessed.

(*Experiment: spark strikes vane on spire and another one appears between clock and lead flashing of roof of nave.*)

It may appear extraordinary that any one should exaggerate this into a flash of lightning extending from the clouds through the air to the clock, but in the partial gloom that accompanies even an afternoon thunderstorm the sudden lighting up of everything by a vivid flash of lightning might lead to the impression that the discharge had been to this spot, where a blinding effect had been seen, especially when afterwards it was found that there was no damage to the spire.

In explanation of the occurrence I may say that the spot really struck was the vane, as in this experiment. The bolt rod of the vane, instead of extending down a few feet only, in the more usual way, was carried down the whole length of the spire, and ended a few feet above the clock works, a piece of copper wire passing near the lower end of the bolt rod to the clock works formed a connecting link between the two. The course of the discharge, therefore, was from the vane, down the bolt rod, through the copper wire (which was fused) to the clock works and face; this part of the path being invisible, not only because it was within an enclosed space, but because it formed a conducting system. Then it passed, as a luminous discharge, through the masonry of the tower, rending it, and then to earth by the lead flashing and gas system.

I may add that my description is not entirely hypothesis. In all the cases I am showing you there were the usual clues that one picks up as ones goes along—clues that might appear insignificant individually, but

which, taken in conjunction with one another, form convincing chains of evidence; but I need not trouble you with the details.

The next case is one that, had it occurred in the way in which it was reported, would have been a real vagary of lightning; would have been contrary to known laws; and we should have had to admit, not only that we know nothing of the subject, but that it is probably beyond human comprehension.

The case was described as follows in a list of reports issued by the recent *Lightning Research Committee* and exhibited at Earl's Court Exhibition in 1903 :—

Feb. 26, 1901.—London. German Lutheran Church, Ritson Road, Dalston.—Flash passed through rose window at north end, leaving stone tracery intact, but destroying the organ immediately behind it and setting fire to timbers of organ loft.

The evidence that appeared to warrant this report was the fact that the spire was uninjured; on the other hand, the north window was destroyed, indicating apparently that lightning had passed through it, and a fire was caused at the north end of the nave, doing, I believe, about £2000 damage. But, according to this report, lightning ignored the tall spire, about 170 feet high, which had a lightning conductor upon it; ignored even the north gable, close to which it was supposed to have passed, that had lead flashing down both sides, which, in conjunction with the rain gutters and down pipes, formed lines of conducting material almost to the ground; it ignored these because it preferred a path of infinitely greater resistance through the air, to curl in through a window some 20 or 30 feet above the ground, being "attracted," I suppose, by some organ pipes!

If lightning had struck the vane on the spire it would not, I presume, have constituted a vagary, so we will put the matter to the test of experiment with this model and see what would have happened if the vane had been struck.

(*Experiment: spark strikes vane on spire and fire is started at meter and spreads up staircase to organ loft.*)

This experiment might be repeated a hundred or a million times with the same result, and the church might have been struck as many times with the same result, provided that the conditions remained precisely the same. There is no vagary about the matter; it is only electricity acting in accordance with one of the best known laws. Attached to the bolt rod of the vane was a lightning conductor, carried down inside the spire and out through one of the windows, where it descended the tower and ended in a rain down-pipe in the corner, so that there was practically no earth connection. The rain pipe was in contact with the lead flashing that passed round the back of the tower to the other side where there was another rain pipe. Near this was a gas lamp set to light the passage, the metal wall plate of the lamp being within a few inches of the rain pipe. The gas pipe passed through the wall into the nave and along to the meter at the north end. So, there were two metallic paths: one the lightning conductor continued by the rain pipe but with an absolutely bad earth connection; the other the lightning conductor continued by the line formed by the lead flashing, rain pipe, and gas pipe, through the

meter to the perfect earth connection afforded by the ramifications of the gas main underground; and lightning took the path of least resistance.

That a fire was caused at the meter, owing possibly to an electrically bad joint, but more probably to crossed inlet and outlet pipes, was a natural consequence; and it was also, I think, a natural consequence that the fire, having started in a cupboard under some wood stairs, should have spread up the staircase to the organ loft, burnt the organ, and melted the leaded lights of the window.

It has been said that abrupt bends in conductors, by increasing self induction, impede the passage of a discharge and cause it to side-flash through rather than go round corners. This statement, in the sense it is obviously intended to convey, is contrary to electrical law; but it has almost got to be accepted as fact, and I should, therefore, like to call your attention especially to the somewhat circuitous course taken by the discharge in this case, the path being down the conductor; up round the back of the tower and down the other side; down the rain pipe; across to the gas lamp; through the wall into the nave; down to nearly the floor level, then along the gas pipe to the north end, then east, and then north again to the main in the road—in all, nine abrupt bends to get to a good earth connection in preference to a perfectly straight course to a bad one.

If I may be permitted to stray for a minute beyond the domain of meteorology into one that might be said to belong more properly to that of engineering, I should like to say that this case shows very clearly, I think, what is after all the crux of the question in protection from lightning, that is, the alternative path of metal, and which, being frequently overlooked, is the cause of many failures of lightning conductors. In order to illustrate still more clearly the importance of the matter, I will repeat the experiment after cutting away the piece of lead flashing that connects one side of the tower with the other, so that this alternative path is no longer open.

(*Experiment: spark strikes vane and fire is started at the meter, as before.*)

A fire is again started at the meter because there is now another alternative path open. I placed a line of lead foil over the south gable to represent lead flashing. If I remember rightly there was none in the original, but its being there did not affect the first experiment, because I purposely left a break of a few inches, which I afterwards made up with a piece of wire, and it now enables me to show you what a roundabout course a discharge will travel and how necessary it is to guard against alternative paths, no matter how circuitous. The course is now down the conductor; along the rain gutter southward; up over the roof and down to the east side; along the rain gutter northward; up over the roof again to the west side; along the rain gutter southward again; down the rain pipe; back to the gas lamp; through the wall; down the gas pipe and along northward; then east, and then north to earth.

It might be asked, "If lightning will go such a roundabout course, how is it possible to protect that building, since, however perfect the lightning conductor in that corner, there is always the alternative path to an earth connection at least as perfect as that of the conductor?" and to forestall that question I may say that the proper position for the lightning

conductor in this case is the south-west corner of the tower, where it would be sufficiently far removed from the dangerous alternative path.

You have doubtless all heard of cases—they are very common—in which lightning has come down a chimney and, after doing some damage, has escaped through an open window or door. When investigating these cases one finds them, as a rule, to be ridiculously simple; but I will show you one that may possess some features of interest.

This model is intended to represent a part of a country hotel, on the upper floor of which was a temporary or extra kitchen with cooking ranges on two sides; one had a brick flue communicating with the chimney stack, the other had a metal flue pipe that passed out through the wall at the back and up above the eaves level, being in connection with the lead rain gutters by metal supports. It was said that lightning, having demolished the chimney stack on the ridge, passed down the flue into the kitchen, dashed across at the cook, giving him a shock and hurling a saucepan out of his hand. Then, apparently finding no one else on whom to wreak its vengeance, it escaped through a window that fortunately happened to be open!

I shall not be able to show you anything that agrees with this account, but I hope to be able to show what really happened. The chimney was wrecked and the cook received a shock. So far the description is correct and so far only.

The shock that the cook received was a very slight one—probably not more severe than he would have taken from a Leyden jar and considered a joke—and the effect I am trying to get in this experiment is proportionally small. In order to render it visible, I have inserted a vacuum tube to represent the body of the cook. I particularly wish to draw attention to the fact that this tube does not lead anywhere except to the representation of the saucepan; yet every time that the chimney is struck you ought to be able to see the vacuum tube lighted up by a feeble discharge passing through it.

(*Experiment.*)

The cook at the moment was poking the fire, having a poker in one hand and a saucepan in the other. The shock he got was not owing to his being in the line of discharge or to lightning travelling his way exactly, but to a mere movement or wave of electrical potential.

The flash that demolished the chimney was conducted by the lead ridge coverings, gutters, and down pipes to earth; but the metal flue pipe, stove, poker, and saucepan formed part of the conducting system—a broadening of it at one part, one might say,—with the body of the cook as a connecting link in the chain, and there would consequently be a surging effect along this chain—a rise and fall of potential,—and the cook felt it.

The fact that the saucepan was flung out of his hand is not a matter for surprise. I have known a man drop a Leyden jar when he has inadvertently discovered that it contained a residual charge after having been discharged.

The next case is one in which a fire was caused in a building covered with corrugated iron sheeting. Some 10 or 12 years ago lightning was said to have struck down inside a brick chimney on the ridge of a small building situated close to Happisburgh Lighthouse. It did not damage

the chimney; it did not even avail itself of the large amount of conducting material afforded by the metal sheeting to get to earth; it passed down the centre of the flue, and then in some mysterious way got to a gas pipe and caused a fire by lighting the gas.

We will now let our mimic flash strike the lighthouse and see what will happen.

(*Experiment: spark strikes vane on lighthouse and gas is lighted in the small building.*)

In explanation I may say that the lightning conductor system in use for English lighthouses is practically that recommended by Faraday in 1843. A stout bar of half-round copper is connected to the metal work of the lantern and carried down inside the lighthouse, being connected to all the metals in the interior. At the bottom it passes out to an ordinary copper-plate earth connection.

On the right is the gas-making house, and a pipe from this passes along underground to the lighthouse and up to the top to provide gas for the lamp, and this pipe is, of course, in connection with the lightning conductor. Another pipe, in connection with the first one, passes along underground to provide light for the small building which was in use at the time, I believe, as men's quarters. There was, therefore, a line of metal, connected to the lightning conductor at the top of the lighthouse, and carried into the small corrugated iron covered building but not connected to the iron framework, there being a small gap between the two, and here, owing to the surging effect I described in the last experiment, a spark would occur, lighting the gas as it has done in this experiment.

We next come to a class of phenomena to which, I think I may say, attention has not been hitherto called, although it might possibly have been inferred from experiments carried out by Sir Oliver Lodge—cases in which objects are struck by lightning and the effects are apparent at some considerable distance away. These cases are by no means uncommon, but they have hitherto been misrepresented owing to their not having been understood.

For instance, a church spire might be struck by lightning, with or without a lightning conductor upon it, and persons in a house at some little distance away, who happened to have metals in their hands at the moment, might receive slight shocks which, however, would perhaps appear severe because they were unexpected. A man walking with a gun on his shoulder, say a hundred yards or so from a tree when it was struck, would most certainly get a shock and say he had been struck too. Workmen handling metal tools are especially liable to these effects when near lightning-struck spots. Quite recently the Vicar of St. Agnes, Scorrier, Cornwall, sent me an account of a thunderstorm in which there was only one flash of lightning, which struck and damaged his church, and he added that men in a mine about 500 yards away and at a depth of 260 to 320 yards below the surface received shocks.

Such cases are generally credited with being marvellous escapes after being struck by lightning, but I would describe them as due to a surging or wave effect, somewhat similar to what I have been showing in the last two experiments, but with the earth as the conductor between in place of a line of metal.

It is often thought that when a lightning flash reaches the earth, to put it in popular language, the effect is all over. Well, it is not.

We must bear in mind that generally before a discharge occurs the potential of a locality is raised, or lowered as the case may be, enormously, and this altered potential does not necessarily return to the normal again without effect. I would liken it to a waterspout forming on the surface of a lake and then suddenly collapsing. The effect would not then be over the moment the column of water struck the surface. There would be a surging or wave effect that might be apparent for some distance. So with a lightning discharge, we may imagine the sudden rise and fall of potential as setting electrical waves flying through the earth, and, where metals were so placed as to give rise to a difference of potential of sufficient magnitude, there the effects would be felt as shocks by persons in the position of links between the metals and the earth, or appear as sparks where metals were placed just in the right way to catch those waves. I may not be placing the matter very clearly or even quite correctly, but it is the way it presents itself to my mind, and I have found it explain many incidents that had appeared mysterious and that could have been foreseen under this aspect of the matter and, it appears to me, under this aspect only.

I have investigated many such cases, but they are difficult to reproduce because of the difficulty of reproducing the exact conditions in a room like this. In the experiment I am about to show you I have to carry it out in a way that makes it approximate somewhat to the last two cases, to which indeed it does bear a resemblance. The greatest distance to which I have so far been able to trace effects of this kind has been half a mile, but I am not prepared to say, if the discharge was exceptionally severe and the conditions especially favourable, that effects might not occur even farther. In the experiment I must be content to have my models a few feet apart.

I do not know that I am altogether justified in quoting the case that I propose showing as an instance of so-called vagary of lightning, since I did not see it so described, but it was regarded as a mysterious case, and it is one of a class that gives rise to descriptions implying vagaries. I have been tempted to select this case principally perhaps because, from seeing the marks where a small fire had occurred at a country station, I was able to deduce the circumstances I am bringing before you, but also because in this case there was a witness.

I was waiting at Heathfield Station in Sussex one day when I noticed marks of burning and a combination of metals that led me to think I had accidentally come across an interesting case, and, having half an hour to spare, I examined the building carefully. I came to the conclusion that lightning had not struck there, although inquiries elicited the fact that the fire had broken out during a thunderstorm. A signalman walking along the line towards the station said he did not see lightning strike there, although he was looking that way and saw the fire occur. I indicated two directions in one of which some object within about half a mile had probably been struck at the same time, and was told that a house just about half a mile away, in one of the two directions I had indicated, had been struck, and, it was believed, at precisely the same time.

The model is intended to represent the railway station. The booking office is on the right and from this a footbridge, with corrugated iron roof leads across the lines to the opposite platform. A gas pipe, rising from the ground, passes up to within a few feet of the iron roofing, and telegraph wires pass down from the roofing to close to the gas pipe, so forming a link between the two. A spark passed between the gas pipe and the iron roof through the telegraph wire, and it was the igniting of the gutta-percha covering of the wires that caused the fire.

(*Experiment: spark strikes house and fire breaks out at the railway station.*)

The limited time at my disposal has permitted me to show only these few cases, but I hope they will serve to convince you that the reports that appear from time to time, of occurrences so extraordinary as to be contrary to scientific knowledge, should be accepted with reserve until they have been investigated by some one competent to judge whether the facts are as reported or open to a simple and reasonable explanation that would show that man might be at fault but not the laws of nature.

DISCUSSION.

Mr. BALDWIN LATHAM said that he had learnt much during the evening with regard to the secondary currents accompanying lightning strokes. It was evident that atmospheric electricity made its way to the largest mass of metal. He had frequently heard of lightning flashes making their way down the lightning conductors of chimney stacks, passing through the chimney shaft into the boilers, and thence seeking the earth, instead of making a direct path from the top of the chimney shaft to the earth through the conductor. After what he had heard he found himself asking, What was a really good earth connection? He thought it would be better for those fixing lightning conductors to seek the best possible advice, so as to avoid the mistakes to which attention had been drawn in the paper.

Mr. J. E. CLARK referred to a lightning flash that had fused a gas-pipe in a narrow alley 300 to 400 yards away from the south-west tower of York Minster. He wondered if any connection had been formed between the gas-bracket and the conductor on the tower by means of water-mains or gas-pipes, or whether the effect was the result of the electric wave surging out 300 or 400 yards from where the discharge had been made.

Mr. W. MARRIOTT said that the Royal Meteorological Society had from its foundation been very much interested in the question of lightning and thunderstorms. It had instituted a number of investigations on the subject, and had also been the means of organising the Lightning Rod Conference in 1878. That body, of which the late Mr. Symons was secretary, had devoted a considerable amount of time to the question of protection from lightning, and had brought out a report of valuable information and a code of rules for the fixing of lightning conductors. The book, however, had been out of print for some years. The Royal Institute of British Architects had recently organised a Lightning Research Committee, which had just brought out a brief report on the same subject; but he (Mr. Marriott) did not think this had in any way upset the recommendations of the Lightning Rod Conference. He was inclined to agree with Mr. Hands that most of the so-called vagaries of lightning were really due to the laxity or vagueness of the descriptions of the occurrences. He quoted several such reports which he had received, including one in which

a correspondent wrote saying that he had received a slight "sunstroke," and he asked if a telephone pole close by had anything to do with it. Mr. Marriott had referred to the weather chart for the day in question, and found that the conditions were favourable for a thunderstorm in the neighbourhood. He therefore suggested that the "sunstroke" was really the action of lightning, and to this his correspondent readily assented. Referring to the last experiment shown by Mr. Hands, he (Mr. Marriott) stated that when at Keswick some time ago he took shelter during a thunderstorm in a tent to escape from the rain, and while there he felt a curious sensation creeping up the body, and when it reached his shoulders it was suddenly dissipated, and was immediately followed by a brilliant flash of lightning. No doubt he was in the influence of the electrical wave or surge that spread up from the earth and which was dissipated by the lightning flash. In connection with this subject he also read the following letter from Mr. H. E. Morris of the Esher Outfall Works to Mr. Baldwin Latham, written on November 23, 1888:—

"You were speaking of the effect which lightning had on the men employed building high chimney shafts. I will tell you my own experience in or about the year 1878. Myself and another bricklayer were building a chimney shaft at Spiers and Pond's steam laundry in the Battersea Park Road, when a heavy thunderstorm came on. While we were striking the joints of our brickwork with one hand resting on the brickwork of chimney there was a flash of lightning; and though it did not appear to be near the shaft it had such an effect on our arms that were resting on the shaft as to cause us very much pain from the finger to the elbow, causing us both to fall against the work, although the pain was only momentary, and we both were down the ladders as soon as possible. I have often heard bricklayers repeat that they had experienced the same thing. In fact the same thing happened to two bricklayers working on these works; for during some flashes of lightning last summer, while we were erecting the shaft, two of the bricklayers came down and complained to me that it was not safe to remain on the shaft, as they had both felt a shock in their arms while in the act of laying a brick. Both told me that their fingers went stiff and their arm appeared paralysed up to the elbow; the other bricklayers, not having a hand on the shaft, felt nothing of the shock, though hearing the others cry out they refused to remain on the shaft while the lightning lasted."

Mr. Alfred Hands, in reply, said that the experiments which he had attempted were all very simple, and indeed, when investigating the effects of nature, they were always to be found capable of a simple explanation. It was only the descriptions of the cases that were extraordinary. With regard to the lightning stroke at Bootham Bar, York, mentioned by Mr. Clark, it was described in the Lightning Rod Conference Report, and had always appeared to him extraordinary. Being in York twenty years after the occurrence, he had investigated the matter, and had fortunately found the place exactly in the same condition as at the time of the thunderstorm. The street was a very narrow one, and the iron pipe of the gas-bracket, which had been lengthened at the top by a compo pipe, was within half an inch or so of the leaden sill of the house; and, as in the case of Heathfield Station fire, if a house within half a mile on the east side was struck, a spark would be liable to occur and fuse the pipe. A good earth connection for the lightning conductor was very necessary, but it was not everything; and care should be taken that rival conductors, such as gas and water pipes, did not form alternative paths and divide the discharge. He had come across many curious examples of bad connections; but the worst that he could remember was that reported by Dr. Mann, at St. Anne's Church, Highgate, where the conductor terminated in a glass bottle. At the great flagstaff in Kew Gardens, the lightning conductor

was brought down to the basement, and then led to an iron tank filled with water, the caretaker having instructions to always keep the tank well filled.

Mr. Hands considered that the Royal Meteorological Society had earned the thanks of the entire world for the valuable work they had done in the preparation of the Lightning Rod Conference Report. No trouble had been spared by the members of the Committee, and every available book on the subject, both in English and in foreign languages, had been consulted and digested, with the result that a very valuable work had been the outcome of their labours. The Conference was held owing to the many failures of lightning conductors that had occurred, and to the consequent loss of faith by the general public in their value. Although open to improvement, the Report was still the best work on the subject, and a reliable guide to the average man. With regard to the work of the Lightning Research Committee, he thought that the less said about it the better. Their work was undertaken from an entirely different standpoint to that of the Lightning Rod Conference.

The PRESIDENT (Mr. R. BENTLEY) said he felt sure the Fellows were much indebted to Mr. Hands for his very valuable paper, and for the interesting exhibition of models of the buildings struck. As far back as the time of the Ancients and the early Egyptians precaution was taken to guard against damage by lightning; and the roof of Solomon's Temple was studded with metal points for the same purpose. In the Middle Ages this provision seems to have been sadly neglected, and Fuller's *Church History* gives a long list of abbeys and cathedrals that had been struck not once but many times. Of late years scientific means had been taken to prevent these occurrences, and now our powder magazines and other public buildings were comparatively safe. No doubt many of the descriptions of these extraordinary effects of lightning arose from the confusion of the moment caused by the suddenness and blinding brilliancy of the lightning flash, and many of the so-called "vagaries" of lightning might be accounted for in this way. With regard to the Heathfield case, it might be mentioned that Heathfield was the only place in the British Islands where petroleum gas (similar to that met with in America and in the Caucasus), was found exuding from the soil; though on the occasion just referred to it did not appear to be responsible for the damage done by fire.

Severe Winter in Mesopotamia.

Mr. H. F. B. Lynch, M.P., writes from the House of Commons:—"May I claim the publicity of your columns in order to bring to the attention of men of science a fact which is also of general interest? The past winter has been one of unusual severity in Mesopotamia—the great alluvial plains watered by the Euphrates and Tigris of which the climate during winter is as a rule so mild. At Baghdad the thermometer has on several occasions registered 10° Fahr., or 22 degrees of frost. A temperature so low as this has never been experienced by any living inhabitant. Fuel has been fetching enormous prices, and the orange plantations in the city and country surrounding have been much damaged. At Mosul the Tigris has been completely frozen over, and it is reported that persons crossed the river on the ice. Great quantities of snow have fallen on the Zagros range, blocking the caravan routes; but these mountains are, of course, far distant from the course of the Tigris through the plains."—*The Times*, May 4, 1906.

NOTE ON THE VALUE OF A PROJECTED IMAGE OF THE SUN FOR METEROLOGICAL STUDY.

By CATHARINE O. STEVENS.

(Communicated by W. Marriott, F.R.Met.Soc.)

[Read April 18, 1906.]

THE object of this paper is to draw attention to the exceptional opportunities for meteorological research that offer in the employment for this purpose of a projected telescopic image of the sun. It has of course long been recognised that the knowledge that is to be gained of the highest regions of the atmosphere by observation of stellar images cannot be dispensed with, however valuable the information that is gained by purely terrestrial means, that is to say, by the flying of kites and balloons for the purpose of barometrical and thermometrical readings, wind pressures, etc.

Looking down as they do through the whole depth of our atmosphere, the stars, by their scintillations, reveal the secrets of the regions that cannot otherwise be made known to us. But stars even of the first magnitude are at best mere points of light upon which to employ our powers of research; and, moreover, they can only be viewed to advantage by means of the more delicately adjusted instruments, while the darkness of night precludes the possibility of any simultaneous observations of cloud-formations.

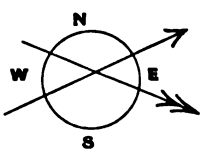
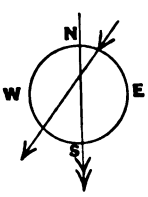
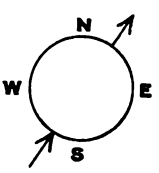
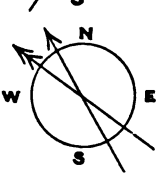
The sun, on the other hand, by virtue of its greater nearness and brilliance, is an easy object for even the smallest telescopes, and has been proved by the present writer to yield the most extensive and reliable evidences of atmospheric conditions bearing upon the structure and movements of the air; so much so, indeed, as to warrant the opinion that it is by the sun's help alone that the problems of the highest regions of the atmosphere are, if ever, to be finally solved.

Amongst the problems that call for special attention, and that may be said to be specially approachable by a study of the sun's projected image, may be cited: 1. The structure of clouds; 2. Their *relative velocities* of movement; 3. Their *actual* rate of transit across the sun's disc, and 4. The stratification of the atmosphere.

By the courtesy of Mr. Marriott of the Royal Meteorological Society, comparison has already been made of certain of the writer's observations (selected at random) with contemporaneous records of "wind and weather." The result of this comparison gave such strong testimony to the correctness of the former, that it was suggested by Mr. Marriott that a note upon the writer's method of observation, together with a tabulated selection of records, would not only be of interest to Meteorologists generally, but likely to yield, on further comparison with other meteorological observations of contemporaneous dates, information at once valuable and suggestive.

Using a small telescope and low magnifying power [3 inch O.G. magnifying = 30 diams. or 1¼ O.G. magnifying = 15 diams.], the sun's

image is projected on to a sheet of white cardboard (preferably in a darkened room) at such a distance from the eye-end of the telescope as to give an image of not less than 4 or 5 inches diameter *within an ample field*. It has been found essential that the sun's image should not itself

Date and Time of Observation.	Direction of Wind or of "Boiling Movements" along the Limb of the Sun.	Character of these Movements.	Character of Clouds.	Casual Observations.
1903 March 4 9 to 9.30 a.m.		...	Clouds continually obscuring the view. The lower stratum → formless, swiftly scudding drift that is intermittent. The upper stratum →→ drifts slowly and steadily in the form of small bosses or nodules of cloud, the front margins of which are more fringed than the hinder. Sometimes these nodules come in *flocks*, and are generally then suggestive of the "ripplemark" cloud formation.	The definition of solar features is good.
April 17 9.20 to 9.50 a.m.		All movements of the sun's limb *very erratic*, temporarily augmented by passage of *visible cloud* —also, and equally so, by what asserts itself in the way of *invisible* vapours.	Clouds change their shapes hardly at all during their transit. The pace is moderate, and the densities from margin to centre of individual cloud-fleeces finely graduated.	Good definition of solar features. Snow early morning, enough to thinly whiten the ground, 7° to 10° of frost.
April 18 9 to 9.20 a.m.		Tremendous boiling, giving no one predominant direction of drift.	...	To naked eye *cloudless day*; dainty grey mackerel sky above, heavy cloud-bank at sunset. Again cloudless sky 11 p.m.; temp. rising, bar. falling slightly.
April 19 9.15 to 9.45 a.m.		Ditto.	...	Again cloudless day.
April 20 9.30 to 9.50 a.m.		Very erratic, showing at least three prevailing directions of drift; predominant direction from S.W.	...	Bar. falling.
April 21 9 a.m.		Rippling movement in waves of small amplitude, confused by the cross currents of cloud strata.	Clouds show visible change in formation (*i.e.* dissolution) as they slowly cross disc. Region of their greatest density is in their hinder parts. The more Easterly drift is in the lower stratum ←←.	

occupy the whole of the field, for there is news to be gleaned from all the neighbourhood of the sun, as far as its light-penetrating powers will allow. But it is necessary, in order to be able to make use of the sun's disc as a unit of measurement from day to day, that the diameter of the sun's projected image should remain constant; for this purpose a circle is traced upon the card, and the sun's image is readjusted to this at every observation.

Other precautions have been taken to secure that there may be no error in judging the directions of drift of the various strata of the air; and further to detect any special feature that might be associated with the height of the sun above the horizon.

By this method it has been finally ascertained, 1. that where the direction of movement of the atmosphere is *tangential* to the limb of the sun the phenomenon of "boiling" displays a *coursing* or *rippling* character; 2. that where the direction of movement of the atmosphere is perpendicular to the limb of the sun (that is to say, at those points upon the disc of "entrance" and "exit" of the drift) the character of the movements of distortion is that of a *springing* in and out of the area of the sun's image; 3. that both these elements of movement are continuous even in the absence of all visible cloud; and 4. that it is possible not only to detect, but also to distinguish between overlying, albeit *invisible*, that is to say, *uncondensed* atmosphere strata.

The accompanying tabulated report of observations, which were made at Bradfield, Berks, 200 feet above sea-level, contains only such details as have hitherto been recorded with regularity. It is regretted that they therefore do not include daily local records of rainfall, wind directions, and readings of the barometer, etc., as these are, clearly, facts to be noted with advantage.

In respect of the evidences as to the stratification of the atmosphere, a few words may be said in conclusion. If atmospheric electricity is ever *generated by friction between cloud masses*, how much more must it be generated in the strata of uncondensed air that are here shown, in the absence of "clouds," to be so persistently superimposed upon one another, and moving, therefore, in so much the more intimate and effectual contact.

DISCUSSION.

Miss C. O. STEVENS amplified the paper by drawing on the black-board, and explained the application of the terms used to distinguish between the several phenomena of "boiling," directing attention to the reliability of these phenomena, severally considered, as indications of prevailing directions of drift of the overlying strata of the atmosphere. When the movements of "rippling" and "springing" were seen to overlap one another, it was to be inferred that more than one direction of drift prevailed; the several currents were then often difficult to decipher, but yet might be accurately distinguished by careful observation. The greatest difficulty was experienced in attempting, in the absence of visible clouds, to determine which one of two superimposed strata might be the higher and which the lower; but evidence went to show that the limb of the sun appeared the more torn as the stratum of the air causing this phenomenon was of lower elevation. Miss Stevens concluded by attributing

the phenomena recorded to the existence of great rivers of air coursing through the yet greater ocean of the atmosphere, the contiguous surfaces of the intersecting strata being ruffled by friction *inter se* into "waves" or "ripples."

Mr. R. INWARDS said that he had seen the boiling and rippling movements, but not so clearly as Miss Stevens had done. The action was clearly not a local one upon the body of the sun itself, as the same tremulous effect could be observed in rocky countries after sunset on a hot sunny day. He would like to know if the observations had always been taken with the sun at the same altitude, as he thought the conditions would be different at various times of the day. He hoped the Fellows of the Society with telescopes would take up this new method of observation, and he thought the Society was to be congratulated on having it brought first before their notice.

Mr. W. H. DINES inquired if it was necessary to have a clockwork attachment to the telescope, so as to keep the image of the sun always in position. Speaking from his experience in kite-flying, he thought it would be found that the upper current nearly always came from the right hand, although there was no fixed rule on the subject. There was no doubt that the different effects of movements described by Miss Stevens were due to the different densities of the air.

Mr. H. MELLISH said that he had never observed the boiling movements of the sun; but in rifle-shooting it was a common practice to estimate the varying strength of the wind by watching in a telescope the rate of travel of the "boil" across the target. On a cloudy day the movements were much less marked than on a bright, sunny day; and although he had not noticed the distinction between the springing and rippling movements, yet the phenomena observed were no doubt similar to those brought forward by Miss Stevens.

Mr. J. E. CLARK inquired whether observations of the moon might not be taken as well as those of the sun. In 1884 he had noticed a remarkable ripple, producing a line of blue sky, moving athwart a high cirrus cloud, and probably caused by a warmer current of air either above or below the layer of moisture-laden air forming the cirrus cloud.

Miss C. O. STEVENS, in reply, said that the smallest telescope—even a spy-glass suitably mounted—sufficed for the observations. As to the observed variations in the amplitude of the wave-length of the "ripplings," these would doubtless be determined by the force and direction of the "friction" giving rise to the "ripplings." It was only by noting such variations that it was possible to discover the existence of overlying invisible strata following one and the same direction of drift. By observations of the moon all the same evidences of atmospheric conditions could be secured, but observations of the sun are more easily and fully legible. Miss Stevens mentioned, in conclusion, that she had journeyed to Majorca last August in order to utilise the opportunity of the total solar eclipse for studying the phenomenon of "shadow-bands" in association with the various phenomena of "boiling": a very complete series of observations was secured, confirming her opinion that "shadow-bands" were in fact the atmospheric "ripples" or "waves" made visible by the projection of their images on the ground under suitable conditions of limited illumination.

The PRESIDENT (Mr. R. BENTLEY) said the paper presented new and interesting possibilities; and although at present we could not determine how far to connect the undulations of the sun with meteorological observations, yet there was much food provided for afterthought. Miss Stevens was to be congratulated on a valuable contribution to the Society's records.

REPORT OF THE COUNCIL

FOR THE YEAR 1905

[Submitted to the Annual General Meeting, January 17, 1906.]

THE Council in presenting their Report for the past year desire to congratulate the Society on its improved position, and on the marked revival of interest in Meteorology throughout the country. The successful inauguration of the new scheme of Lectures and Exhibitions should greatly extend the work and influence of the Society, both in London and in the provinces, and it is hoped will lead to yet further advancement of its objects. The number of Fellows is now 674, showing a considerable increase in the year.

Committees.—The Council have been materially assisted during the year by the following Committees:—

EDITING COMMITTEE.—The President, Messrs. Bayard, Inwards, and Scott.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Dines, Inwards, Latham, and Wilson-Barker.

KITE COMMITTEE.—The President, Secretaries, Lieut.-Col. Capper, R.E., and Messrs. Curtis, Dines, and Hepworth.

LOCAL SCIENTIFIC SOCIETIES COMMITTEE.—The President, Secretaries, Treasurer, Messrs. Dickson, Druce, Hopkinson, Shaw, and Sir J. W. Moore.

Meteorological Office Grant.—The Meteorological Council has been reconstituted by the Treasury as an Advisory Committee, with Dr. W. N. Shaw as Director of the Meteorological Office. It is a matter of regret that this Society is not officially represented on the Meteorological Committee or on the Board of Visitors of the Royal Observatory, Greenwich.

Symons Memorial Medal.—The Council, at their meeting on November 15th, designated Lieut.-General Sir Richard Strachey, G.C.S.I., F.R.S., the late Chairman of the Meteorological Council, as the recipient of the Symons Gold Medal for 1906, in consideration of his eminent services to the science of Meteorology.

Howard Medal.—The Howard Silver Medal, for which Cadets of the Nautical Training College, H.M.S. *Worcester*, are eligible, was awarded to Cadet Barnes for the best essay on "Ocean Currents in relation to Winds and other Meteorological Elements."

Exhibition.—The Council considered that the time had again arrived for holding an Exhibition of Meteorological Instruments, the last having taken place in 1897. Accordingly, by the kind permission of the President and Council of the Institution of Civil Engineers, a large and interesting Exhibition, consisting mainly of self-recording instruments, was arranged in the Library of the Institution, and was open from March 14th to 17th. The exhibits were 205 in number. The President, at the meeting on March 15th, delivered an address on "The Growth of Instrumental Meteorology," which was illustrated by portraits of some of

the earlier meteorologists. On the afternoons of the days on which the Exhibition was open, Mr. W. Marriott gave a brief address descriptive of the exhibits. The Exhibition was visited by about 1000 persons, including the pupils of several schools under the charge of their teachers.

Kite Committee.—The work of this Committee has been continued. The British Association granted £40 in the year 1904 towards the purchase of instruments. The special observations this year were, through the kindness of the Royal National Mission to Deep Sea Fishermen, made from the Mission steamer *Queen Alexandra* in the North Sea. Mr. Dines being unable to take charge of the observations, these were, at the request of the Committee, carried out by Mr. G. C. Simpson. Mr. Simpson's account of the experiments was read before the Society at the December meeting.

The important investigations of the upper air, successfully undertaken under the direction of this Committee in concert with the British Association, have led to the appointment recently of Mr. W. H. Dines to undertake the supervision of further experiments and researches to be made on behalf of the Meteorological Office.

Though no longer able, on this account, to take so active a part in the work of this Committee, it is hoped that Mr. Dines will still find time to continue to assist in its deliberations. The Council avail themselves of this opportunity to express their high appreciation of the very valuable services Mr. Dines has rendered to the Society over so long a period, especially in connection with the kite observations and the preparation of the apparatus and instruments for aerial exploration, a task of greater difficulty in the pioneer and experimental stages than it now is.

The British Association has reappointed its Committee to co-operate with the Kite Committee in carrying on the work.

Local Scientific Societies Committee.—The scheme elaborated by this Committee and approved by the Council has already been put into operation, a guarantee fund exceeding £150 having been first raised to protect the Society against risk of loss. A circular letter was sent out to the Secretaries of the Local Scientific Societies, Public Schools, Education Committees, and also to the Fellows, which has elicited 265 letters of enquiry and necessitated the writing of 227 letters in reply. The Council have appointed Mr. W. Marriott as the Lecturer, and the exhibits are sent out in charge of a member of the staff. During the last three months eighteen lectures have been delivered in various parts of the country, and selected exhibits have been shown at Rochester, Walsall, and Rochdale. Arrangements have also been made for 11 Lectures during the coming year, and two important Exhibitions are under consideration. The Council are encouraged by the progress of the scheme, and trust that it will diffuse, by degrees, a sound knowledge of the principles of Meteorology throughout the country, and incidentally lead to the strengthening of the Society. In connection with this subject the Council refer with gratification to the success of the Society's exhibit at the Royal Agricultural Society's Show at Park Royal from June 27th to 30th, which His Majesty The King, and our Patron H.R.H. The Prince of Wales, inspected.

Optical Convention.—A Convention of persons interested in the construction and use of Optical Instruments was held from May 31st to June 3rd, and Mr. Inwards attended as the Society's representative.

Research Fund.—This fund is represented by £68 : 12 : 9 in Consols. It has not been necessary during the past year to make any inroad upon this somewhat slender amount, which it is hoped may be augmented before occasion arises for a further call upon the fund.

Meetings.—With the exception of those in February, May, and June, which were held in the Society's Rooms, the Meetings took place as usual, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster.

Quarterly Journal.—The volume for 1905 consists of 340 pages, and contains the papers read at the meetings of the Society, with an abstract of the discussions that followed, numerous notices of meteorological interest, especially the translations by Dr. R. H. Scott of two papers from the *Meteorologische Zeitschrift*, on "Rain" by P. Lenard, and on "The Anomalies of the Weather in Iceland, 1851-1900, and their Relation to the Simultaneous Weather Anomalies in North-Western Europe," by J. Hann. The section of "Meteorological Literature" has been continued.

Meteorological Record.—Three parts have been issued during the year, bringing the publication up to March 1905.

Hints to Meteorological Observers.—As the stock of this publication was exhausted, the Council requested Mr. Marriott to prepare a new edition, the sixth, and decided that 2000 copies should be printed. The Council have directed that a copy of this edition should be sent free of charge to every Fellow who intimates a desire to receive it.

Stations.—Observations have been accepted from one new station, Market Drayton, Shropshire.

Inspection of Stations.—All the stations in the north and north-east of England, and such others as could be conveniently visited, were inspected, and found to be, as a whole, in a satisfactory condition. Mr. Marriott's report will be found in Appendix II., p. 212.

Phenological Report.—This valuable report, the fourteenth in succession prepared by Mr. E. Mawley, was read by him at the February meeting. The Society owes its best thanks to Mr. Mawley for his persevering labours in collecting and discussing the returns of no less than 115 stations, and in maintaining communication with so large a body of special observers.

Office Work.—Owing to the large amount of extra work occasioned by the Exhibition of Instruments in March, and the Exhibit at the Royal Agricultural Society's Show in June, and also by the new scheme of Lectures and Exhibits in connection with the Local Scientific Societies, the ordinary work of the Office has fallen somewhat in arrear. The Council hope that arrangements may soon be made for bringing the work up to date, and trust that an increase in the number of Fellows

will justify the additional outlay which the reorganisation of the office work may entail.

Library.—The additions to the Library are given in Appendix V, p. 224. Mr. A. W. Preston has made a valuable contribution by his present of the MS. Journals of Mr. Thomas Pallant, kept at Palgrave and Redgrave, Suffolk, 1786-1842.

The Library now consists of the following:—Vols., 8607; Pamphlets, 11,777; Maps and Charts, 213; Manuscripts, 866; and original Observation Books, 140.

Meteorological Bibliography.—During the year, 4581 cards have been prepared for the Society's Bibliography. This consists of the titles of all books, pamphlets, papers, and articles bearing on Meteorology, of which any notice can be found. In addition to the above, 463 catalogue cards of the titles of works bearing on Meteorology, published in the British Isles, have been prepared for the *International Catalogue of Scientific Literature.*

The Council have to express their recognition of the courtesy of the Editor of the *Geographical Journal*, London, for supplying advance proofs of that valuable monthly Bibliography.

Fellows.—The changes in the number of Fellows are given in the following table:—

Fellows.	Annual.	Life.	Honorary.	Total.
1904, December 31	**495**	**144**	**19**	**658**
Since elected . . .	+58	+ 6	...	+64
Since compounded .	− 1	+ 1	...	0
Deceased	− 6	− 5	− 2	−13
Retired	−27	...	...	−27
Removed from List .	− 4	...	...	− 4
Lapsed	− 4	...	...	− 4
1905, December 31	**511**	**146**	**17**	**674**

Deaths.—The Council regret to have to record the loss by death of thirteen Fellows, including some who had achieved high distinction. These include two Honorary Members, Prof. P. Tacchini of Rome in April and Dr. R. Billwiller of Zurich in October, and two Fellows who have done good work for the Society, viz. the Rev. T. A. Preston in February and Mr. S. W. Silver in March. The Rev. T. A. Preston undertook the collection and discussion of the Phenological observations from 1875 to 1888. Mr. Silver's position as Trustee from 1866 to 1892, when his duties came to an end by the abolition of the office, was of a very responsible character, and his interest in the Society never flagged. The premature death of Mr. Mansergh is also to be deplored.

Dr. Robert Billwiller (Hon. Mem.)	elected	May	18, 1892.
Maj.-Gen. B. R. Branfill	,,	Nov.	17, 1869.
William Henry Curtin	,,	Jan.	15, 1900.
Miss Emma Ann Dymond	,,	May	15, 1878.
William Horton Ellis, J.P.	,,	Aug	26, 1851.
Charles Horsley, M.Inst.C.E., F.R.A.S., F.G.S.	,,	Feb.	16, 1881.
James Mansergh, F.R.S., M.Inst.C.E.	,,	Feb.	15, 1882.
Capt. Henry Robert Frederick Plater, F.R.G.S.	,,	Feb.	20, 1895.
Rev. Thomas Arthur Preston, M.A., F.L S.	,,	June	15, 1864.
Alfred T. Rapkin	,,	Apr.	21, 1875.
Stephen William Silver, F.R.G.S., F.L.S.	,,	June	6, 1860.
Frederick Slade, Assoc. M.Inst.C.E.	,,	Apr.	21, 1880.
Prof. Pietro Tacchini (Hon. Mem.)	,,	May	18, 1892.

CONTRIBUTIONS TO THE LOCAL SCIENTIFIC SOCIETIES FUND.

	£	s	d
Royal Meteorological Society	5	0	0
Alexander, P. Y.	10	0	0
Allen, A. C.	1	1	0
Anderson, J. A.	1	1	0
Bayard, F. C.	2	2	0
Bentley, R.	21	0	0
Bertodano, C. E. de	1	1	0
Blake, T. N. (the late)	1	1	0
Black, Dr. W. G.	2	2	0
Brocklehurst, S.	5	0	0
Bromhead, C. J.	1	1	0
Broome, J.	1	1	0
Brown, I. J.	0	10	6
Cave, C. J. P.	5	0	0
Chilvers, G. W.	1	1	0
Clarke, Capt. M. H.	0	10	6
Cuninghame, R. J.	1	1	0
Dickson, Dr. H. N.	2	2	0
Dines, W. H.	2	2	0
Druce, F.	10	0	0
Edmonds, F. B.	2	0	0
Groves, W. G.	1	1	0
Gyles, N.	1	1	0
Hall, P. C.	1	1	0
Harmer, F. W.	5	0	0
Carry forward	£84	0	0

	£	s	d
Brought forward	£84	0	0
Hodgson, H. T.	1	1	0
Howard, W. D.	2	2	0
Inwards, R.	1	1	0
Kelly, Major A. D. D.	1	1	0
Lamont, R.	5	0	0
Latham, B.	5	5	0
Lee, L. G. H.	0	10	6
Lempfert, R. G. K.	1	1	0
Maclear, Admiral J. P.	1	0	0
Mellish, H.	5	0	0
Mill, Dr. H. R.	2	2	0
Munro, R. W.	1	1	0
Newby, H.	1	1	0
Parker, Rev. Dr. J. D.	2	2	0
Rivington, C. R.	2	2	0
Rylands, Mrs.	5	0	0
Scott, Dr. R. H.	2	2	0
Shaw, Dr. W. N.	5	0	0
Sibthorpe, Col. F. R. W.	10	0	0
Thompson, A. G.	0	10	0
Williams, Dr. C. T.	21	0	0
Wilson, A.	0	10	6
Wilson-Barker, Capt. D.	1	1	0
	£160	13	0

APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1904			£122 5 11
Subscriptions for 1905	£842 0 0		
Do. for former years	68 0 0		
Do. paid in advance	39 0 0		
Life Compositions	147 0 0		
Entrance Fees	52 0 3		
			1148 0 3
Meteorological Office—Copies of Returns	£99 9 0		
Do. Grant towards Inspection Expenses	25 0 0		
			124 9 0
Dividends on Stock (including £47 : 19 : 10 from the New Premises Fund)			142 1 7
Sale of Publications, &c.			43 12 5
			£1580 9 2

OR THE YEAR ENDING DECEMBER 31, 1905.

EXPENDITURE.

Journal, &c.—			
uarterly Journal, Nos. 133 to 136	£174 15 0		
llustrations	27 1 11		
uthors' Copies	15 6 0		
leteorological Record, Nos. 94 to 96	68 0 6		
		£285	3 5
Printing, &c.—			
eneral Printing	£22 5 0		
tationery	30 12 1		
ooks and Bookbinding	9 18 6		
llustrations for Hints to Meteorological Observers	4 5 0		
		67	0 7
Office Expenses—			
alaries	£563 1 6		
ent	212 0 0		
oals, Lighting, and Insurance	11 11 9		
urniture and Repairs	1 4 6		
ostage	83 13 2		
etty Expenses	14 16 9		
efreshments at Meetings	13 4 2		
wo Howard Medals	2 8 6		
		902	0 4
Exhibition—			
eneral Expenses	£35 7 11		
rinting and Catalogue	20 4 6		
		55	12 5
Observations—			
Inspection of Stations	£49 17 11		
Observers	11 4 0		
Instruments	1 15 3		
		62	17 2
Lectures—			
Contribution to Local Scientific Societies Fund		5	0 0
		£1377	13 11
Balance—			
At Bank of England	£195 14 1		
In hands of the Assistant-Secretary	7 1 2		
		202	15 3
		£1580	9 2

Examined, compared with the vouchers, and found correct,

January 10, 1906.

T. P. NEWMAN,
E. S. BRUCE, } *Auditors.*

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

Subscriptions paid in advance	£39 0 0	
Rent for quarter ending December 25, 1905	53 0 0	
Meteorological Record, No. 97	17 15 0	
General Printing and Stationery	5 18 6	
		£115 13 6
Excess of Assets over Liabilities		3474 11 5
		£3590 4 11

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND

Amount paid to the Society's Fund towards the rent of offices at 70 Victoria Street	£47 19 10

RESEARCH FUND,

Balance from Kite account for 1904	£48 5 10
Interest on Investment	1 14 0
Anonymous Donation for Kite Observations	25 0 0
Amount withheld in 1903 from payment for hire of Tug	12 13 4
	£87 13 2

I.—continued.

ON DECEMBER 31, 1905.

ASSETS.

Great Central Railway 4½ per cent Debenture Stock, £800 at 131¾	£1054	0	0			
New South Wales 4 per cent Inscribed Stock, £654:18s. at 105½	690	18	4			
London & North-Western Railway Consolidated Stock, £400 at 160¾	643	0	0			
London & North-Western Railway 4 per cent Preference Stock, £12 at 121½	14	11	7			
Annuities, 2½ per cent, £231:11:9 at 88¼	204	7	6			
				£2606	17	5
Subscriptions unpaid, estimated at	£60	0	0			
Entrance Fees unpaid	17	0	0			
Interest due on Stock	54	18	3			
Meteorological Office—Weekly Returns, 1905	28	16	4			
				160	14	7
Furniture, Fittings, &c.	£488	0	9			
Instruments	131	16	11			
				619	17	8
Cash at Bank of England	£195	14	1			
Cash in hands of the Assistant-Secretary	7	1	2			
				202	15	3
				£3590	4	11

Examined, and Securities seen at the Bank of England,

January 10, 1906.

T. P. NEWMAN,
E. S. BRUCE, } *Auditors.*

DECEMBER 31, 1905.

Interest received on Investment	£47	19	10	

Note.—The Society hold on account of this Fund £1443:7:9 South Australian 3½ per cent Inscribed Stock.

Examined,

January 10, 1906.

T. P. NEWMAN,
ERIC STUART BRUCE, } *Auditors.*

DECEMBER 31, 1905.

Expenses connected with the Kite Observations at Oxshott	£17	3	1	
Do. do. do. in the North Sea	19	8	0	
	£36	11	1	
Balance in hand—Research Fund	1	14	0	
Kite Fund	49	8	1	
	£87	13	2	

Note.—The Society hold on account of this Fund £68:12:9, 2½ per cent Consols.

Examined,

January 10, 1906.

T. P. NEWMAN,
E. S. BRUCE, } *Auditors.*

APPENDIX

SYMONS MEMORIAL

Balance from 1904	£18 8 10
Interest received on Investment	18 18 1
	£37 6 11

LOCAL SCIENTIFIC SOCIETIES'

Contributions as per List (p. 207)	£160 13 0
Lectures—Fees and Expenses	41 2 0
Exhibits—Fees and Expenses	16 3 3
	£217 18 3

APPENDIX II.

INSPECTION OF STATIONS, 1905.

All the stations in the north and east have been visited, and were found to be in a generally very satisfactory condition.

The number of thermometers tested has been 179, in 30 of which changes of zero were found to have taken place, viz.: Dry-bulb 5, Wet-bulb 8, Maximum 3, Minimum 6, Grass Minimum 3, and Earth Thermometers 5.

I have often pointed out the desirability of the observer occasionally unclamping the screws round the cistern of his barometer, in order to see that the instrument is hanging quite perpendicularly. There was a striking instance of the need of this at Buxton, where, owing to a settlement of the hut in which the barometer was placed, the top of the barometer required to be brought forward more than half an inch in order to get the instrument to hang freely within the ring round the cistern.

Haze is often reported at Rounton. I had an opportunity of seeing the

I.—continued.

MEDAL FUND, 1905.

Cash at Bank of England, December 31, 1905			£37 6 11
			£37 6 11

Note.—The Society holds on account of this Fund £630 Cardiff Corporation Redeemable Stock, 3 per cent.

Examined,

January 10, 1906. T. P. NEWMAN, E. S. BRUCE, } *Auditors.*

FUND, 1905.

Lecturer's Fees and Expenses			£37 19 0
Exhibitor's Fees and Expenses			14 12 6
Exhibit at Royal Agricultural Society's Show			13 15 9
Instruments			5 13 4
Lantern Slides			8 11 10
Packing Cases, &c.			2 14 10
Printing			2 4 6
			£85 11 9
Balance—			
Deposit at London and Westminster Bank			100 0 0
Cash at Bank of England			32 6 6
			£217 18 3

Examined,

January 10, 1906. T. P. NEWMAN, E. S. BRUCE, } *Auditors.*

haze come on while I was there. This must be largely due to smoke from the Stockton and Middlesborough furnaces. On the way to Darlington I could see the southern portion of the Cleveland hills most clearly and distinctly, but the northern portion was completely obscured by the smoke cloud.

WM. MARRIOTT.

October 14, 1905.

NOTES ON THE STATIONS.

APPLEBY, *July* 18.—I recommended that the maximum thermometer should be put a little on the slant in order to prevent the mercury running up the tube ; and also that the posts of the screen should be strengthened to prevent vibration.

BELPER, *August* 18.—There was no change in the zeros of the thermometers The screen required painting. Mr. Hunter has a barograph, and also contemplates having an electric self-recording rain-gauge.

BLACKPOOL, *July* 22.—The instruments are now placed in a large enclosure in a field, and have a very open exposure. I suggested a rearrangement of the thermometers in the screen. The Snowdon rain-gauge has Baxendell's arrangement for melting snow. Halliwell's self-recording rain-gauge is also in use. The Negretti and Zambra self-recording rain-gauge is not in use. The sunshine recorder is mounted on a staging above the roof of the Observatory building: the exposure is good. The head of the Dines pressure-tube anemometer is mounted a considerable height above the Observatory roof, the recording part being in the room below. The instrument seemed to be in good order. The slab of the sunshine recorder required fixing in order to prevent the instrument being shifted. A Richard barograph had recently been purchased, and was to be placed in the Observatory. The solar thermometers were placed in a cage of close wire netting, and so were not fully exposed. I recommended that the cage be removed.

BOLTON, *August* 23.—On comparing the thermometers it was found that all the earth thermometers had gone up 0°·1, and that the grass minimum had gone down 0°·5. The column of mercury in the maximum thermometer was broken by an extra air speck, and so was liable to give too high a reading, as it did on this day. I therefore recommended that the spare maximum thermometer be used. Some trees to the east of the sunshine recorder make an angle of 8°, and so intercept a little of the early morning sunshine. Mr. T. Midgley now takes the observations.

BOWNESS, *July* 20.—I urged that a fresh card be put in the Jordan recorder each day, whether there had been any sunshine or not. The recorder was set for lat. 50°. A few days previously a piece of coal dust had got into the hole of the recorder, and stopped the sunshine for some hours.

BRUNDALL, *September* 6.—This station was in good order. On comparing the thermometers it was found that the wet-bulb had gone up 0°·2. As Mr. Preston was removing from Brundall at the end of the month, I went to his new house in Christchurch Road, Eaton, Norwich, and selected a site for the instruments.

BUXTON, *August* 19.—The barometer was not hanging vertically, the upright on which it was fixed having got out of level. The top of the board had to be brought forward six-tenths of an inch. I arranged with the Secretary of the Hospital for the removal of the barometer from its present position into the main building. The mercury in the cistern of the barometer was very dirty and required cleaning. There was no change in the zeros of the thermometers, but the maximum seemed to be too low when set. The mercury index was also a very long one, with a liability of the air bubble working into the bulb. I suggested that another thermometer might perhaps be obtained. The observations are now taken mostly by a youth who is the librarian at the Y.M.C.A.

CHEADLE, *August* 17.—On comparing the thermometers it was found that the grass minimum had gone down 0°·3. The muslin on the wet-bulb was of too fine a texture. I recommended that the minimum thermometer should be hung quite horizontally in order to prevent the index being shaken down by the wind.

CORTON, *September* 7.—The sunshine recorder was in good order. The trees have grown so much that they now make an angle of 8° or more. It is therefore necessary that the recorder should be considerably raised, or that it should be moved to a more open situation. The thermometer screen required painting and the sheet of zinc on the roof removing.

DERBY, *August* 17.—The thermometer screen required new legs, and also painting. The muslin on the wet-bulb was much too thick. It would be an advantage if the muslin and cotton were changed more frequently.

ELY, *September* 5.—This station was in good order. I recommended that attention be paid to the growth of the trees, so that they might not influence the instruments.

HARROGATE, *August* 25.—On comparing the thermometers it was found that the maximum had gone up 0°·3, and that the minimum had gone down 0°·2. I recommended a rearrangement of the thermometers in the screen. The sunshine recorder required readjusting; the ball also had slipped down a little at the back, and needed clamping more firmly.

HILLINGTON, *September* 5.—On comparing the thermometers it was found that the maximum and the dry-bulb had both gone up 0°·2, and the wet-bulb 0°·1. The ball of the sunshine recorder is cemented to the pedestal. A chimney on the west-south-west makes an angle of 9° with the recorder, and may cut off a little of the afternoon sun in the spring and autumn. The Rev. H. Ffolkes takes great interest in the observations, but owing to ill-health he experiences great difficulty with them.

HODSOCK, *August* 28.—This station was in good order. Mr. Mellish has a Halliwell self-recording rain-gauge, and he is also arranging for a Dines thermograph.

KESWICK, *July* 18.—This station was in good order. On comparing the thermometers it was found that the wet-bulb had gone up 0°·2.

LANCASTER, *July* 21.—The instruments were in the same position as formerly. On comparing the thermometers it was found that the wet-bulb had gone up 0°·2. The Beckley rain-gauge was working better than at my last visit, but the pen did not descend quite to the bottom of the sheet. As the sunshine was not properly measured, I requested that the cards should be sent up for remeasurement.

LINCOLN, *August* 30.—A new 8-in. rain-gauge had recently been obtained. I recommended that the top branches of an apple tree on the east-north-east of the gauge should be cut off. On comparing the thermometers it was found that the dry-bulb and wet-bulb had both gone up 0°·1. The electrical thermometer on the tower of the Cathedral seemed to be in good working order.

LOWESTOFT, *September* 7.—This station was in good order. The tubes of the dry-bulb and the maximum thermometers had slipped down a little. These I readjusted and wedged up with cork, so that the divisions on the tubes should correspond with those on the scales. I recommended that the upper parts of the earth thermometers should be painted white. Since my last inspection the post of the sunshine recorder has been raised 8 ft. The trees on the south-east and south-west have, however, so grown up that they now make an angle of 7°. I recommended that the trees be lopped or the recorder raised. On comparing the thermometers it was found that the minimum had gone down 0°·2.

MACCLESFIELD, *August* 21.—The minimum thermometer was broken on December 22 in trying to get some spirit down from the top of the tube. A new thermometer was obtained through the generosity of the Mayor. I urged the observer to pay more attention to the wet-bulb in frost.

MARKET DRAYTON, *August* 22.—Mr. Wright removed his instruments from Mellington Hall, Churchstoke, and set them up in his garden at Market Drayton. He, however, only takes the observations at 9 a.m. There was no change in

the zeros of the thermometers. The grass minimum had some spirit at the top of the tube. The sunshine recorder required adjusting. As the exposure is interfered with on the east by a tree, I suggested that the recorder be raised up higher.

MELTHAM, *August* 24.—A second 1-foot earth thermometer is placed in the grass plot near the rain-gauge. The instruments were in good order.

RAUNDS, *September* 19.—The instruments are placed on the lawn and have a good exposure. As the thermometer screen was closed in at the bottom, I recommended that a number of holes be bored in it, and also several at the top. The thermometers required rearranging in the screen. The rain-gauge was fixed in a drain-pipe with a large lip near the funnel. I recommended that the lip be chipped away to obviate insplashing of rain, and also that holes be made in the flange of the cylinder to drain it, and so prevent freezing in winter. On comparing the thermometers it was found that the dry-bulb and wet-bulb had both gone up 0°·2, and that the minimum had gone down 0°·2.

RAVENSCAR, *July* 12.—The thermometers were in good order, except the minimum, which had the spirit broken up, with over 50° at the top of the tube. I succeeded in setting the thermometer right, and in putting it into working order. The rain-gauge needed repairing, the rim being partly detached from the funnel. The Rev. A. L. Becker, owing to ill-health, had to discontinue the observations in the winter, but he resumed them at the end of June.

ROTHBURY, *July* 15.—There was no change in the thermometers. The sunshine recorder was not in proper adjustment; the ball was too high, and the frame was set to lat. 50° instead of 55½°. I put the instrument into proper adjustment.

ROUNTON, *July* 13.—The observations are now carried on under the authority of Sir Hugh L. Bell, Bart. Owing to structural alterations, the barometer will soon have to be moved to another position. On comparing the thermometers it was found that the grass minimum had gone up 0°·6. The index of the maximum is now only 4° in length. Haze is often reported at this station. I had an opportunity while there of seeing it come on. The haze must be largely due to smoke from the Stockton and Middlesborough furnaces. On the way to Darlington I could see the southern portion of the Cleveland hills most clearly and distinctly, but the northern portion was completely hidden by the smoke cloud.

SCALEBY, *July* 17.—The conducting thread of the wet-bulb was very thin, and seemed hardly sufficient for keeping the muslin moist. I recommended that the thermometer screen be strengthened by cross-pieces being put on the legs.

SCARBOROUGH, *July* 11.—Since the last inspection the instruments have been moved from the Peasholme Allotments to the lawn in front of St. Nicholas House. This is on the top of the cliff, which has an eastern aspect. The meteorological conditions are apparently not quite the same as at the former site, the new one evidently being warmer. I took a Richard thermograph with me, and placed it in the screen in order to ascertain whether the anomalous readings are supported by the continuous records. A large circular iron lattice screen was placed round the rain-gauge. I recommended that it be lowered. The sunshine recorder is placed on the tower of the Fire Station and has a good exposure. The trace was not running quite parallel with the card, the instrument not being quite level. The slab was fixed in cement, so I could not alter it. The thermometer screen required painting.

SCARBOROUGH (MANOR ROAD), *July* 11.—The minimum had some spirit up the tube. Mr. A. Thompson seemed much interested in the observations. I suggested to him that he might take cloud and wind observations. He has had a little difficulty at times with the wet-bulb in frost.

SEATHWAITE, *July* 19.—The legs of the thermometer screen required strengthening by cross-pieces. The bottom of the cylinder of the rain-gauge was broken off, so I took it to Keswick to be repaired. The two other rain-gauges were all right. I requested Mrs. Jackson to send up the original observation book every month.

SOUTHPORT, *July* 24.—Everything at this station was in good order. The Jordan sunshine recorder has been discontinued. Experiments are being made with two Campbell-Stokes recorders, with the view of seeing whether they give the same results, and also whether different kinds of cards yield the same amounts. A Dines thermograph has been placed in a separate Stevenson screen. A Dines barograph with enlarged scale has been mounted in the Astronomical Observatory.

SOUTHWOLD, *September* 8.—The grass minimum had some spirit up the tube. The muslin and cotton on the wet-bulb needed changing. The Jordan sunshine recorder is now mounted on the anemometer post in the meteorological enclosure. The church tower on the south-east cuts off some of the sunshine in the spring and autumn. On comparing the thermometers it was found that the dry-bulb had gone up 0°·2 and the wet-bulb 0°·1, and that the minimum had gone down 0°·3.

STRELLEY, *August* 16.—The minimum had 0°·3 of spirit at the top of the tube. On comparing the thermometers it was found that the dry-bulb had gone up 0°·1. The thermometer screen required painting. Mr. Edge will probably move the screen at the end of the year to a more open situation, and also have an additional rain-gauge. The trees on the east of the sunshine recorder make an angle of 10°.

USHAW, *July* 14.—There was no change in the zeros of the thermometers. The thermometer screen needed repairing and strengthening.

WAKEFIELD, *August* 24.—The rain-gauge was in need of repairs. I was informed that a new one had been applied for. The air bubble in the maximum thermometer seemed to be getting too near the bulb; the detached column of mercury being very long. I recommended that the column be shortened by placing the bulb in a mixture of salt and ice. The muslin on the wet-bulb needed changing. Owing to the smoky atmosphere of the neighbourhood, the muslin is soon liable to get corroded unless it is frequently washed. I urged that this be regularly attended to. I saw the two warders who take the day observations; and by permission of the Governor I also went to the prison and saw the night warder take the 9 p.m. observations.

WOODBRIDGE, *September* 9.—I called to see Col. Carthew's sunshine recorder. This is placed on a stone pedestal on the lawn. The exposure, however, is not very good, as trees cut off the morning and evening sun. There did not appear to be any more suitable site. The thermometer screen is placed at the other end of the lawn. On comparing the thermometers it was found that the dry-bulb and wet-bulb had gone up 0°·2 and the maximum 0°·1.

WRYDE, *September* 4.—The muslin was rather baggy on the wet-bulb. I urged that it be kept tight round the bulb. New maximum and minimum thermometers had recently been obtained. The column of mercury in the maximum was liable to break owing to specks of air. I requested that this should be carefully looked to.

APPENDIX III.

OBITUARY NOTICES.

ROBERT BILLWILLER, who died on August 14, 1905, was born on August 2, 1849. He studied at Zürich, Göttingen, and Leipzig. In 1871-2 he went to Berne under the direction of Rudolf Wolf, where he soon became head of the Meteorological Observatories under the Swiss Naturforschenden Gesellschaft.

In 1874 he became head of the service at Zürich; and in 1881 this was made a Government Department, and Billwiller its head.

He was the author of over 70 papers.

Dr. Billwiller was elected an Honorary Member of this Society on May 18, 1892.

WILLIAM HENRY CURTIN was born at Hull on May 13, 1859. He was appointed Assistant Sanitary Inspector for the East District of Hull in 1890, and became Chief Inspector for the same district shortly afterwards.

In 1897 he was appointed Chief Sanitary Inspector of Lincoln, which position he retained until his death.

He was stricken with typhoid fever on February 1, 1905, and died on the 14th of the same month.

He was highly respected by all who came in contact with him either in business or otherwise. The officials of the Corporation of Lincoln marked their appreciation by erecting a memorial tombstone on his grave, which contained the following inscription: "Erected by the Officials of the Corporation in token of their regard for his character and work."

Mr. Curtin was elected a Fellow of this Society on January 15, 1902. He was also an Associate Member of the Royal Sanitary Institute.

EMMA ANN DYMOND was the daughter of Robert Dymond of Exeter, a well-known suryeyor and engineer in the West of England, who died in 1866, and sister of Edward Ernest Dymond of Aspley Guise, who died in 1904. She was a Member of the Society of Friends, and was interested in various charities, and in Protestant movements, especially the Waldensian Missions in Italy. She had great literary tastes, and was an excellent scholar in Italian and Italian Art. She had lived a somewhat retired life with her elder brother, Mr. F. W. Dymond, for nearly forty years at Exeter, and died, after a few weeks' illness, on April 18, 1905, aged 65 years.

She took rainfall observations from 1867 to the time of her death.

Miss Dymond was elected a Fellow of this Society on May 15, 1878.

WILLIAM HORTON ELLIS was born at Exeter in 1832. The greater part of his life was passed in that city, in whose welfare he always took the greatest interest. For many years he carried on business as a silversmith in the High Street.

He was elected Sheriff in 1873, and was Mayor for two successive years, 1878 and 1879. During his term of office the public Abattoir was opened, and he was also largely responsible for the formation of the Arcade and Eastgate Companies. He was chairman of both companies up to the time of his death. He was also chairman of several other companies.

In 1891 he went to live at Budleigh Salterton, until his death from heart disease on May 6, 1905.

Mr. Ellis was elected a Fellow of this Society on August 26, 1851, at the age of 19. He was much interested in meteorological and sanitary matters, and he took rainfall observations at Exeter from 1855 to 1878.

CHARLES HORSLEY was born on May 30, 1829, at Pye Bridge, Derbyshire, and educated at Derby Grammar School. After a few years spent at various engineering works he came to London and acted as agent and consulting engineer to Messrs. James Oakes & Co., of Alfreton, Derbyshire, a position he held until his death. He invented a gas exhauster and also a patent syphon, which have since been extensively used. He was elected a Member of the Institution of Civil Engineers in 1883, and was President of the Society of Engineers in 1881.

For many years he was an active member of the magisterial Bench for Middlesex, and in 1887 was one of the 60 chosen to carry on the work during the time that the Cities of London and Westminster were being amalgamated under the title of County of London. He was a member of the first London County Council, and was for 18 years Chairman of the East Islington Conservative Association.

Mr. Horsley was elected a Fellow of this Society on February 16, 1881. He died on January 4, 1905.

JAMES MANSERGH was born at Lancaster on April 29, 1834, and was educated at Harmony Hall, Hampshire. In 1849 he was apprenticed to Messrs. H. M'Kie and Lawson, engineers and surveyors, of Lancaster; and subsequently he went to Brazil as engineer to Mr. E. Price, contractor for the Dom Pedro II. railway from Rio de Janeiro to the interior. Returning to England in 1859, Mr. Mansergh joined his old master, Mr. M'Kie, at Carlisle, doing general engineering work and laying out the first sewage-farm in England. Subsequently Mr. Mansergh again turned his attention to railway work, and from 1862 to 1865 he was contractor's agent for Messrs. John Watson and Co., being engaged first on the Mid-Wales and then on the Llandilo and Carmarthen railway, in the latter case undertaking practically all the usual work of a railway engineer. In 1866 he entered into partnership with his brother-in-law, Mr. John Lawson, at Westminster, his first work being the laying out of a gravitation scheme of water supply for Carlisle. Before Mr. Lawson's death in 1873 the partners designed and carried out, wholly or in part, sewerage, waterworks, and drainage systems for numerous places in the provinces and abroad. They were associated in 1870-1 with Sir Robert Rawlinson in reporting for the Corporation of Birmingham upon the water supply for that town, when Mr. Mansergh suggested the scheme adopted more than twenty years later for utilising the valleys of the Elan and Claerwen, with which he had become acquainted while working on the Mid-Wales railway eight years before.

After Mr. Lawson's death Mr. Mansergh designed and constructed sewerage works at a number of places. He was also in constant request in connection with Parliamentary work. In 1878 he prepared by special request a scheme for the sewerage of the lower Thames valley drainage district which is under twenty separate local authorities. In 1879 he acted for the Thames Conservators in their arbitration with the Metropolitan Board of Works on the question of obstruction to navigation caused by mudbanks in the Thames near the two sewage outfalls; and four years later was one of the chief witnesses before Lord Bramwell's Commission on Metropolitan Sewage Discharge.

One of the most important pieces of work which he undertook was that of advising the Government of Victoria upon the sewerage of Melbourne and its environs, an area of 133 square miles. Mr. Mansergh went to the colony in 1889 and spent eight weeks in investigation. The complete scheme which he finally drew up was the largest of its kind ever designed, the estimated cost being £5,816,500.

It is, however, in connection with the Birmingham water scheme that Mr. Mansergh's name will be best remembered. In 1890 he was again

consulted by the Corporation of Birmingham, and finally reported once more in favour of the Elan and Claerwen scheme, the value of which had been impressed upon him in early days. He utilised completely a watershed area of 71 square miles, and the rainfall upon it, by providing six storage reservoirs with stone dams, varying from 98 feet to 128 feet in height, and containing in all 17,614 million gallons. This area suffices to provide 27 million gallons per day as compensation to the River Elan, and 75 millions for the supply of Birmingham and the towns adjacent to the aqueduct. The water is conveyed by a conduit having 13½ miles of tunnel, 23 miles of cut and cover, and 37 miles of iron or steel pipes crossing valleys, with service reservoirs, filter-beds, and many important accessory works. His Parliamentary estimate for this scheme was £5,851,000.

He also carried out numerous other schemes of sewerage and sewage disposal, and prepared reports on sewerage and water-supply projects for a large number of places in this country and abroad.

Mr. Mansergh was a Member of the Institution of Civil Engineers, and was President in 1900. He was also a Member of the Institution of Mechanical Engineers; and was elected a Fellow of the Royal Society in 1901.

He died on June 15, 1905, after many weeks' illness.

He was elected a Fellow of this Society on February 15, 1882.

Rev. THOMAS ARTHUR PRESTON was born in Dean's Yard, Westminster, October 10, 1833, his father being a master at Westminster School. He held two Scholarships at Emmanuel College, Cambridge, came out twentieth in the list of Wranglers in 1856, and in 1857 headed the First Division in the Natural Sciences Tripos, with especial distinction in Botany and Mineralogy. He was ordained as Deacon in 1858 and Priest in 1859, in which year he proceeded M.A. In 1858 he received an appointment as Assistant Master at Marlborough College in the Lower School, and from 1873 to 1885 he was a House Master there and also in charge of the Mathematical Class.

Though at first finding Wiltshire somewhat barren ground after Cambridgeshire, his industry of observation and energy in exploration caused him to modify this view, and his enthusiasm in outdoor survey induced others to co-operate with him. After five years' residence on the spot Mr. Preston brought out his *Flora of Marlborough, with Notices of the Birds and a Sketch of the Geological Features of the Neighbourhood.* He was also Founder, and for sixteen years President, of the Marlborough College Natural History Society.

Mr. Preston was a member of the Conference on Observations of Natural Periodical Phenomena organised by the Royal Meteorological Society in 1874, and he assisted in the preparation of the *Instructions for the Observations of Phenological Phenomena.* At the request of the Council he undertook the collection and discussion of the Phenological Observations made by the Society's observers; and he carried on this work from 1875 to 1888, since which time it has been continued by Mr. E. Mawley.

He carried on most valuable and complete meteorological observations at Marlborough from 1864 to 1884, and spared no expense to ensure that they were correctly and regularly taken. In 1885 he published his *Results of 20 Years' Observations on Botany, Entomology, Ornithology, and Meteorology taken at Marlborough College*, 1865-1884. He was the founder of an organisation for the collection of rainfall statistics for Wiltshire, and published the daily observations in *Wiltshire Rainfall* from 1875 to 1885. This publication was then taken over and continued till 1893 by the Rev. C. Soames and others. In 1888 he published a book on *The Flowering Plants of Wilts.*

In 1885 he was offered the living of Thurcaston, near Leicester, which he held until his death on February 6, 1905.

The Rev. T. A. Preston was not only himself a most careful observer, but succeeded in inducing his pupils to record anything of interest in a methodical way. He arranged a Botanical Garden at Marlborough, and was constantly organising lectures or discussions in his rooms, as well as planning field excursions for his pupils. His enthusiasm was infectious. Little bands of followers attended him armed with hammers, butterfly-nets, moth-boxes, and botany-tins. His room before tea-time was a notable sight. Hither were brought the miscellaneous spoils of a half-holiday raid: flowers on the chance of being "a first find," butterflies, moths, flints, coins, etc., for identification or examination by the master.

After he had been a few years at Marlborough, Mr. Preston gave a series of lectures on Botany, Zoology, Comparative Anatomy, and Physiology: a somewhat new departure in those days, as Science Masters and Laboratories had not then been introduced at our Public Schools. These were very stimulating, questions being invited and answered. The lecturer's munificence enabled fine specimens or valuable instruments to be provided.

When Mr. Preston took the living at Thurcaston, he found it heavily encumbered, and he left it free. While there he rearranged the Botanical section of the Leicester Museum, and took part in the direction of the Scientific and Philosophical Societies of that town. He also continued his phenological, rainfall, and sunshine observations.

For the last few months he suffered from a distressing complaint which he bore with great fortitude and patience. He was a man of strong and simple Christian faith, a devoted brother, a fast friend, genuine as pure gold, and singularly modest.

He was elected a Fellow of this Society on June 15, 1864, and was a Member of the Council in 1876 and 1877.

Stephen William Silver was born in London in 1819. In 1846 he succeeded to the management of the export and banking business founded by his father—a business having its agents and correspondents in all parts of the world. Messrs. S. W. Silver and Co.'s monthly *Circular* soon merged itself into an *Emigrants' Guide*; that in time expanded into a series of *Handbooks* to each group of colonies in Australasia, Canada, South Africa, and the West Indies; while to these publications was added the fortnightly, afterwards weekly newspaper, the *Colonies and India*.

After his retirement from the City business, Mr. Silver continued for many years chairman of the India-Rubber and Telegraph Company, having its works at Silvertown. He was also a Director of the London Life Association, a Past-Master of the Ironmongers' Company, and a Deputy-Lieutenant of the City of London; Governor of St. Thomas's, St. Bartholomew's, and Bridewell Hospitals; and was a Fellow of many Scientific Societies, in all of which he took a very active interest. He was also a member of the Committee of the British and Foreign Bible Society.

Without any pretence as a scientific geographer, Mr. Silver was yet well informed upon the progress and results of modern exploration. Few men could follow the course of a traveller more intelligently; indeed, he was minutely acquainted with the routes of African explorers, and intimate with Livingstone and Moffat, Burton and Speke, Baker and Consul Petherick, Cameron, Holub, Selous, Thomson, and many more. One was always certain of meeting visitors from different parts of the world at his table, either at his club or at his town house, York Gate; a favoured few were made welcome at the "Benhams," Letcomb, where Mr. Silver was long privileged to exercise the influential position of a "Lord of the Manor." To many travellers he gave useful advice, and, where necessary, extended a helping hand. At York

Gate Mr. Silver had collected his valuable geographical and colonial library, which was always accessible to visitors and searchers. He considered himself amply repaid by the use young students made of the collection, and was more than gratified when the printed catalogue found its way into some of the principal libraries as a work of reference.

In February 1905 he caught cold on the lungs, and was confined to his house at York Gate for two or three weeks. He apparently made a quick recovery, and was permitted to return to Letcomb; but he had a relapse and died on March 7, at the ripe age of 85.

Modest, unassuming, and unostentations in all his doings—it was only upon very rare occasions that his voice was heard—Mr. Silver took a personal interest in the welfare of every one with whom he associated. He will be missed far beyond his own immediate circle of friends, which is a very large one, and remembered for his kindly and agreeable manner by all who came in contact with him.

Mr. Silver was elected a Fellow of this Society on June 6, 1860. He served on the Council from 1862 to 1894, and was a Trustee from 1866 to 1892, when that office was abolished.

FREDERICK SLADE was born on November 28, 1823. After some practical experience, in 1846 he entered the service of Messrs. Thedwell Brothers, who at that time were engaged on the construction of the Berks and Hants Railway from Reading to Basingstoke. In August 1847 he was engaged for a short time on the Bathampton and Bradford Railway, and, on the stoppage of that work in January 1848, he was employed as contractor's engineer on that portion of the Oxford and Rugby Railway between Oxford and Banbury. From January 1851 to October 1854 he occupied a similar position on the Oxford, Worcester, and Wolverhampton Railway between Worcester and Tipton. He was then employed from 1854 to 1857 again on the Bathampton and Bradford Railway, which enterprise included two aqueducts under the Kennet and Avon Canal and some heavy timber viaducts of 80-feet span over the River Avon. From 1857 to 1859 he was in charge of the Southall and Brentford Railway and Dock, the quay walls of which consist of a series of piers built at right angles to the wharf. On these the arches rested which carried the platform for cranes, turn-tables, etc. He also directed the construction of a somewhat novel bridge near the Hanwell Asylum, where the railway was taken under the Grand Junction Canal and turnpike road at the same spot by one bridge. From 1859 to 1863 he was employed as contractor's agent in superintending the construction of the High Wycombe and Thame Railway, and from 1863 to 1864 on the Winwick and Golborne Railway. From 1864 to 1868 he had charge of the work in the construction of the Porthcawl Harbour and Docks in South Wales; and from 1868 to 1872 that of the Bristol Harbour Improvements, which consisted of a new lock from the River Avon to the Cumberland Basin, and another from the Cumberland Basin to the Floating Harbour, and also easing off some of the curves of the River Avon and straightening its course, which made it more navigable for larger vessels.

On the death of Mr. W. Thedwell, who was the last of the Thedwell Brothers contractors, in 1871, Mr. Slade was appointed to superintend the construction of the Ramsden Dock, Barrow-in-Furness, where he remained till the completion of the dock in 1879.

From 1879 to 1883 Mr. Slade resided at Kenilworth, and during the latter part of that time he was Chairman of the Local Board when the sewerage and sewage disposal of that town were carried out. In 1883 he removed to Beckford, near Tewkesbury, where he interested himself in astronomy and meteorology. He had a complete record of the weather from day to day since

1872, which he plotted on monthly charts bound in annual volumes. These records he bequeathed to the Royal Meteorological Society. He died on December 11, 1905, aged 82 years.

Mr. Slade was elected a Fellow of this Society on April 21, 1880. He was also an Associate Member of the Institution of Civil Engineers.

PIETRO TACCHINI was born at Modena in 1838. He graduated as a prizeman in Engineering at the Academy of Modena, and afterwards studied astronomy at the Observatory of Padua. At the early age of 21 years he was called to take charge of the Observatory of his native city, but four years later left this position on being appointed to the staff of the Palermo Observatory.

In 1879 he became Director of the Astronomical Observatory and of the Central Meteorological and Geodynamical Institute in Rome, and in this office he was for many years one of the central figures in Italian astronomy and spectroscopy. His principal interest was in solar physics; observations of the sun were carried on regularly during practically the whole period of his scientific activity, and for thirty years he organised Italian eclipse expeditions as opportunity offered. He was one of the chief founders of the Società degli Spettroscopisti Italiani in 1872, and edited its *Memorie*, in which much of his own work was published.

In 1873, writing on the connection between solar prominences and the Aurora Borealis, he stated that the relationship was closer between these phenomena than between sun-spots and the Aurora. In 1874 he observed the transit of Venus in Bengal, and from his spectroscopic investigations inferred the existence on Venus of an atmosphere similar to our own. In 1883 he went with Janssen to Caroline Island to observe the total solar eclipse, and made the discovery of *white* prominences; this was confirmed in the 1886 eclipse, when Tacchini observed a white prominence 150,000 miles in height.

He was elected an Associate of the Royal Astronomical Society in 1883, and was awarded the Rumford Medal of the Royal Society in 1888. In 1891 he was elected a Foreign Member of the Royal Society, and in the following year received the Janssen Medal of the Paris Academy.

His work as Director of the Meteorological Institute was carried on with great activity, and to him is due the establishment of the Italian forecasting service.

He founded and was President of the Italian Seismological Society.

He died at Spilamberto, in the province of Modena, on March 24, 1905.

He was elected an Honorary Member of this Society on May 18, 1892.

APPENDIX IV.

PURCHASES DURING THE YEAR 1905.

BOOKS.

KILGOUR, W.—Twenty Years on Ben Nevis. 8°. Paisley, 1905.

LUNARDI, V.—An Account of the First Aërial Voyage in England. 8°. London, 1784.

M'PHERSON, J. G.—Meteorology, or Weather explained. 8°. London, 1905.

OPTICAL CONVENTION, 1905. Catalogue of Optical and General Scientific Instruments. 4°. [London, 1905.]

PAMPHLETS. Meteorology. 8°. 7 vols.

PROCEEDINGS OF THE ROYAL GEOGRAPHICAL SOCIETY. 8°. London, 1885-92. Vols. 7-14.

SCIENTIFIC YEAR-BOOK FOR 1905, edited by Major B. F. S. Baden-Powell. 8°. London, 1905.

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1905.

1. Books and Pamphlets.

Presented by Societies, Institutions, etc.

Aachen, Meteorologische Observatorium.—Deutsches Meteorologisches Jahrbuch, Aachen, 1903.

Adelaide, Observatory.—Report of Inter-State Astronomical and Meteorological Conference held at Adelaide, May 1905.

Bangalore, Central Observatory.—Meteorology in Mysore, 1904.—Report on the Rainfall Registration in Mysore, 1904.

Barbados, Colonial Secretary's Office.—Returns of Rainfall in Barbados, 1905.

Batavia, Magnetical and Meteorological Observatory.—Rainfall in the East Indian Archipelago, 1903.

Belgrade, Observatoire Central.—Bulletin Mensuel 1 and 2.

Berlin, Deutsche meteorologische Gesellschaft.—Meteorologische Zeitschrift, Dec. 1904 to Nov. 1905.

Berlin, Gesellschaft für Erdkunde.—Zeitschrift, 1904, No. 10 to 1905, No. 9.

Berlin, Königlich-Preussisches meteorologisches Institut.—Anleitung zur Anstellung und Berechnung meteorologischer Beobachtungen.—Bericht des Internationalen Meteorologischen Komites. Versammlungen zu Paris 1900 und zu Southport 1903.—Deutsches Meteorologisches Jahrbuch, 1904, Preussen und benachbarte Staaten.—Ergebnisse der Arbeiten am Aëronautischen Observatorium, 1904.—Ergebnisse der Niederschlags-Beobachtungen, 1901.

Bidston, Liverpool Observatory.—Report of the Director, 1904.

Birmingham and Midland Institute.—Records of Meteorological Observations taken at the Observatory, Edgbaston, 1904.

Bognor, Climatological Society.—Report, 1904.

Bordeaux, Société d'Océanographie du Golfe de Gascogne.—Les courants du Golfe de Gascogne, par C. Bénard.—Rapports présentes à l'Assemblée générale de Janvier 1905.

Bremen, Meteorologische Station.—Deutsches Meteorologisches Jahrbuch, 1904. Freie Hansestadt Bremen.

Brisbane, General Register Office.—Annual Report on the Vital Statistics of Queensland, 1904.

Brisbane, Queensland Geographical Society.—Queensland Geographical Journal, 1903-5.

British East Africa, Agricultural Department.—Meteorological Records, 1904.

Brussels, Académie Royale de Belgique.—Annuaire, 1905.—Bulletin de la classe des Sciences, 1904, No. 12 to 1905, No. 8.

Brussels, Observatoire Royale de Belgique.—Annales Astronomiques 8 and 9, part 1.—Annales, Nouvelle Serie, Physique de Globe, 1 and 2.—Annuaire Astronomique, 1906.—Annuaire météorologique, 1905.

Bucharest, Institut météorologique de Roumanie.—Buletinul lunar al observatiunilor meteorologice, 1904.—Materiale pentru Climatologia Romaniei, Nos. 20 to 24.—Moyens d'investigation en météorologie, by S. C. Hepites.—Starea udometrica si agricolă a Romaniei, June 1904 to April 1905.

Budapest, K. ung. Reichsanstalt für Meteorologie und Erdmagnetismus.—Bericht über die Thatigkeit, 1903.—Die Temperaturverhältnisse von Ungarn von S. Róna und L. Fraunhoffer.—Jahrbuch 1901, Thiel 4; 1902, Thiel 1 and 3; 1902, Thiel 3. 2tes Verzeichness für die Bibliothek im Jahre 1903.

Buitenzorg, Institut Botanique de l'état.—Observations météorologiques, 1902.

Cairo, Société Khédiviale de Géographie.—Bulletin, 6, Nos. 6 to 8.

Cairo, Survey Department, Public Works Department.—Meteorological Observations made at various places in Egypt, July 1904 to June 1905.—Meteorological Report, 1902.—The Rains of the Nile Basin in 1904, by Capt. H. G. Lyons.

Calcutta, Meteorological Department of the Government of India.—Copies of Monsoon Forecasts submitted to Government in June, August, and September, 1904, and a Comparison with the Actual Rainfall.—Indian Daily Weather Reports, Dec. 1, 1904, to Nov. 30, 1905.—Indian Meteorological Memoirs, 16, part 2.—Monthly Weather Review, July 1904 to April 1905.—Rainfall of India, 1903.

CAMBRIDGE, MASS., ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.—Annals, 58, part 1.

CAPE TOWN, METEOROLOGICAL COMMISSION.—Report, 1903, and for the year ending June 30, 1904.

CAPE TOWN, SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Report, 1904.

CAPE TOWN, SOUTH AFRICAN PHILOSOPHICAL SOCIETY.—Transactions, 15, part 3, to 16, part 2.

CARLSRUHE, CENTRALBUREAU FÜR METEOROLOGIE UND HYDROGRAPHIE IM GROSSHERZOGTHUM BADEN.—Jahrbuch, 1904.—Niederschlags-beobachtungen der meteorologischen Stationen im Grossherzogthum Baden, 1905, part 1.

CHEMNITZ, KÖNIGL.-SÄCHSISCHES METEOROLOGISCHES INSTITUT.—Dekaden-Monatsberichte, 1903.

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COLORADO, COLLEGE OBSERVATORY.—Annual Meteorological Summary, 1904.

COPENHAGEN, DANSKE METEOROLOGISKE INSTITUT.—Bulletin météorologique du Nord, Dec. 1904 to Oct. 1905.—Nautisk-Meteorologisk Aarbog, 1904.

CORDOBA, ACADEMIA NACIONAL DE CIENCIAS.—Boletin, 17, part 4; 18, part 1.

CORDOBA, OFICINA METEOROLOGICA ARGENTINA.—Carta del Tiempo, Nov. 1904 to Oct. 1905.

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DUBLIN, DEPARTMENT OF AGRICULTURE AND TECHNICAL INSTRUCTION FOR IRELAND.—Scientific Investigations, 1902-3, No. 9. Quarterly Observations of Temperature, s.s. *Helga*.

DUBLIN, GENERAL REGISTER OFFICE.—Weekly Returns of Births and Deaths, 1905.

DUBLIN, ROYAL DUBLIN SOCIETY.—Economic Proceedings, 1, parts 5 and 6.—Scientific Proceedings, 10, part 2, to 11, part 5.—Transactions, 8, No. 6, to 9, No. 1.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, 25 A., part 3.

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GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Le Globe, 44.

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HAMBURG, DEUTSCHE SEEWARTE.—Annalen der Hydrographie und Maritimen Meteorologie, 1905.—Aus dem Archiv, 1904.—Deutsche Ueberseeische meteorologische Beobachtungen, Heft 13.—Die Wirksamkeit des Sturmwarnungswesens an der deutschen küste.—Ergebnisse der meteorologischen Beobachtungen, 1903.—Erklarüng der von Deutschen Seewarte in den Witterungsberichten und Wettervorhersagen angewandten Ausdrücke.—Jahresbericht, 1904.—Nachtrag zum Katalog vi.—Tabellarische Reiseberichte nach den meteorologischen Schiffstagebüchen.—Wetterbericht, 1905.

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JERSEY, OBSERVATOIRE ST. LOUIS. — Bulletin des Observations magnétiques et météorologiques, 1904.—La théorie hydrothermodynamique des tourbillons atmosphériques.

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LONDON, BRITISH BALNEOLOGICAL AND CLIMATOLOGICAL SOCIETY.—The Journal of Balneology and Climatology, 1905.

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LONDON, INSTITUTION OF ELECTRICAL ENGINEERS.—Journal, Nos. 170 to 175.

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2. PHOTOGRAPHS.

ARCHER, W. H.—Hoar Frost.

BAXENDELL, J.—Downholland Brook Level Gauge near Formby, Southport.

BRUCE, W. S.—Magnetic Observatory and Omond House, Scotia Bay, South Orkneys (2 photos.).

HAWORTH, H. S.—Photographs of Clouds.

THOMAS, J. L.—Photographs of Men struck by Lightning, Cardiff (9 photos.).

3. LANTERN SLIDES.

MAWLEY, E.—Phenological Observations, 1904 (10 slides).

NEGRETTI and ZAMBRA, Messrs.—Meteorological Instruments (15 slides).

STUBB, J.—Lightning (3 slides).

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 21, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

CHARLES ANTHONY, Jun., M.Inst.C.E., Buenos Aires, Argentina;
LEO CLAUDE WALLACE BONACINA, 3 Greencroft Gardens, Hampstead, N.W.;
Miss EDITH HELENA CORDNER, 6 St. Oswald's Road, West Brompton, S.W.;
ROBERT HINDE DOUGLAS, F.R.G.S., Hong Kong;
RAJA KUSHAL PAL SINGH, M.A., LL.B., Kobla, District Agra, India;
ROBERT HUNTER RHIND, Briarside, Cuckoo Road, Hanwell, W.;
ARTHUR SCHUSTER, F.R.S., Victoria Park, Manchester;
MARK SUTTON, Rio de Janeiro; and
WILLIAM J. WARE, Maidstone Waterworks, Maidstone,
were balloted for and elected Fellows of the Society.

Dr. H. R. MILL gave a Lecture on "SOUTH AFRICA AS SEEN BY A METEOROLOGIST," which was illustrated by lantern slides (p. 177).

On the motion of the PRESIDENT, seconded by Mr. BAYARD, a cordial vote of thanks was passed to Dr. MILL for his Lecture.

April 18, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

KHOSHRU NOWROSJI BANAJI, Baroda, India;
ROBERT CROSS, West Hill Lodge, Hampstead, N.W.;
Miss EVANGELINE HALSEY, Washwood Heath Road, Birmingham;
LIANG MING TING, Tientsin, North China; and
Rev. FREDERICK WILLIAM WALTER, Burnham Overy Staithe, King's Lynn,
were balloted for and elected Fellows of the Society.

The following communications were read:—

1. "SOME SO-CALLED VAGARIES OF LIGHTNING REPRODUCED EXPERIMENTALLY." By ALFRED HANDS, F.R.Met.Soc. (p. 189).

2. "NOTE ON THE VALUE OF A PROJECTED IMAGE OF THE SUN FOR METEOROLOGICAL STUDY." By Miss CATHARINE O. STEVENS (p. 199).

CORRESPONDENCE AND NOTES.

The Green Flash.

The extraordinary explanation of the above, referred to on page 159 of the *Quarterly Journal* for April 1906, by Mr. R. C. Cann Lippincott, needs some correction.

He refers to the well-known fact that after gazing fixedly for some time at a brightly coloured spot, then, if the gaze is directed on a white or lightly tinted surface, a spot of the original form but of a complementary colour will appear on that surface.

But such a complementary coloured spot will only fade away slowly, whereas the green flash is momentary, seldom exceeding 1½ seconds.

Again, on the sun rising from below the horizon, the observer has not been steadily gazing at a red sun previous to the appearance of the green flash, for the simple reason that the sun has not been visible. How then can there be any cause for a complementary colour?—ALFRED CARPENTER, R.N., Red House, Sanderstead.

The rising or setting sun appears to make a notch in the horizon. This is probably the reason why observers may see the ends of the segment of the complementary spectrum of the rising or setting sun of a greenish or bluish-green colour while the centre is still white or yellow.—R. C. CANN LIPPINCOTT.

Meteorological Work at the Radcliffe Observatory, Oxford, 1905.

The usual meteorological observations and automatic registrations have been maintained, and the results forwarded regularly as heretofore to the Meteorological Office (by daily telegram), the Registrar-General, the Thames Conservancy, the Metropolitan Water Board, local newspapers, to public and sanitary authorities, and numerous private inquirers.

During the year 1905 the five underground platinum thermometers were in daily use. At the request of the Director of the Meteorological Office daily comparisons have been made between the platinum thermometers and two ordinary mercurial thermometers of Symons' underground pattern at depths of 6 ins. and 3 ft. 6 ins.

All the automatic instruments have worked well during the year.

The following are the chief characteristics of the weather noted at Oxford during the year 1905 :—

The mean reading of the barometer (reduced to 32°) was 29·771 ins., which is 0·046 in. higher than the mean for the preceding 50 years. The highest reading, 30·763 ins., occurred on January 29 ; this reading is the highest recorded at this Observatory since the barograph was mounted in March 1880. The lowest barometrical reading in 1905 was 28·675 ins. on March 15.

The mean temperature of the air for the year was 48°·9, which is exactly the mean value deduced from the readings of the past 77 years. The maximum temperature was reached on July 21, viz. 81°·2 ; and the lowest, 21°·5 on January 20. The lowest reading of the thermometer exposed on the grass was 14°·5 on January 19.

The differences of the mean monthly temperatures from the corresponding means for the preceding 77 years are—

January . .	−0°·2	May . .	+0°·2	September . .	−1°·1
February .	+2·5	June . .	−0·2	October . . .	−4·3
March . .	+3·3	July . .	+3·3	November . .	−1·8
April . . .	−0·9	August .	−0·8	December . .	+0·3

Bright sunshine was recorded during 1439 hours, or 18 hours less than the mean for the preceding 25 years. The monthly differences from the mean are indicated in the following table :—

	hours.		hours.		hours.
January . .	+35	May . .	+32	September . .	−23
February . .	+ 6	June . .	−49	October . . .	+18
March . . .	+ 9	July . .	+36	November . .	+ 4
April . . .	−59	August .	−21	December . .	− 6

Rainfall on the ground amounted to 21·397 ins., a total of 4·702 ins. less than the mean for the preceding 90 years. The number of "rainy days" (*i.e.* 0·010 in. and over) was 133. The divergences of the monthly totals from the corresponding mean values for the previous 90 years were—

	ins.		ins.		ins.
January .	−1·212	May .	−1·169	September .	−1·349
February .	−1·259	June .	+1·517	October . .	−1·673
March . .	+1·585	July .	−1·899	November .	+0·902
April . .	+0·172	August	+0·802	December .	−1·118

A brilliant display of aurora was observed during the evening of November 15.—ARTHUR A. RAMBAUT, *Radcliffe Observer*, *May* 18, 1906.

Cold Nights at Hodsock in April 1906.

The accompanying table gives some of the values for April 1906, and for comparison the averages for 27 years (rain 30 years, sun 25 years), and the values for 1892 and 1893, which had certain resemblances to this year:—

MEAN DAILY TEMPERATURE.

						Frosts.			
April.	Max.	Min.	Mean.	Range.	Min. on Grass.	Screen.	Grass.	Rain.	Sunshine.
								ins.	hrs.
Average 27 years	54·5	36·6	45·5	17·9	30·2	8	17	1·68	131·7
1906	56·5	31·6	44·0	24·9	23·3	17	27	0·62	197·0
1892	56·1	32·3	44·2	23·8	23·1	17	25	0·72	160·0
1893	62·0	35·4	48·7	26·5	28·7	9	19	0·34	217·7

It will be seen that the deficiency of temperature was entirely at night, the mean maximum being 2° above the average. April 1893 had a still larger daily range with less rain and more sun than April 1906, but the temperatures were on an altogether higher level. In April 1892 there was less sun and rather more rain than this year, but the temperature conditions were very similar though not quite so extreme. The mean minimum this year, 31°·6, is lower than in any of the previous 27 Aprils, and is very little higher than the average value for January (31°·3); it is also lower than for any month of the past winter, except February (30°·5). The extreme minimum 23°·5 is not exceptionally low for April, but is lower than any reading during the past winter except one, November 20, when it was the same. In 1903 the April frosts did an unusual amount of damage to vegetation, but the average night values were not so low as this year, and the damage caused was in consequence of vegetation being very forward that spring after an unusually mild February and March.

In the following table are given the mean hourly temperatures during the night hours for the past six months, from which it is seen that from 11 p.m. to 7 a.m. inclusive, the average temperatures in April were as low as, or lower than, those in any of the months during the winter except February, while at 4 and 5 a.m. they were lower even than in February:—

	10 p.m.	11.	Mid.	1 a.m.	2.	3.	4.	5.	6.	7.
Nov. 1905	39°·3	38°·9	38°·7	38°·7	38°·8	38°·7	38°·5	38°·3	38°·1	37°·9
Dec. ,,	38·6	38·4	38·3	38·6	38·3	38·4	38·0	38·0	37·9	37·7
Jan. 1906	40·0	40·1	40·3	39·7	39·6	39·8	39·6	39·6	39·4	39·5
Feb. ,,	35·0	34·7	34·3	34·5	34·3	34·1	34·1	34·0	33·8	33·6
Mar. ,,	39·1	38·7	38·3	38·0	37·7	37·4	37·1	36·9	36·7	37·0
Apr. ,,	38·8	37·4	36·2	35·8	34·9	34·3	33·9	33·6	34·0	37·0

H. MELLISH, Hodsock Priory, Worksop.

Cyclonic Storm, January 21-23, 1906.

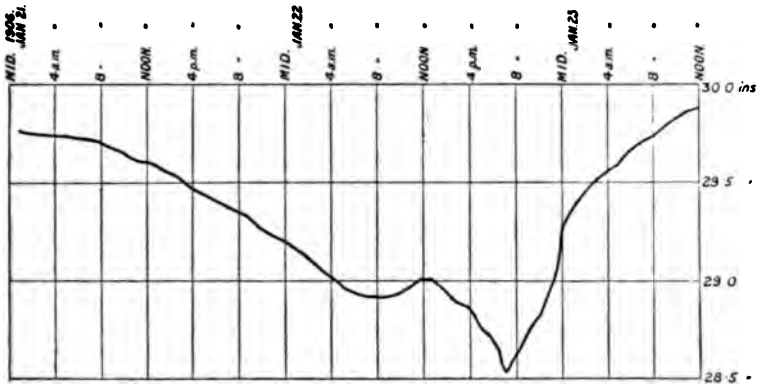
Capt. Hepworth, the Marine Superintendent of the Meteorological Office, has forwarded the following interesting letter from Capt. W. G. Lingham:—

I beg to enclose some particulars of a very severe cyclonic storm experienced on the s.s. *Wilcannia* during the passage from Cape Town to Adelaide.

The weather from 6.0 to 11.0 p.m. on January 22, 1906, was of a fearful description, and the violence of wind and sea exceeded anything I have met

with in 26 years of sea-life. I doubt if anything but a powerful and well-found ship would have lived through it.

You will note from the barograph trace enclosed the extraordinary fall in the barometer from 1.0 to 7.0 p.m., and the still more rapid rise from 7.0 p.m. to midnight. From 11.0 to 11.30 p.m. it rose ·29 of an inch, the ship having steamed about 3 knots in that time.



Record from Barograph.

At 9.0 p.m., shortly after the first rise of the barometer, I and my officers estimated the force of the wind at fully 80 miles per hour, while the spume and spray going clean over the fore-track, 130 feet from sea-level, the ship making 3 to 4 knots headway, wind abeam.—W. GEORGE LINGHAM, F.R.A.S, Master s.s. *Wilcannia*.

Notes on the Cyclonic Storm experienced by the s.s. Wilcannia, *between Cape Town and Adelaide.*

January 21.

Noon.	E.b.N., a fresh breeze, densely overcast. Smooth sea.
4 p.m.	E., a fresh breeze, densely overcast. Smooth sea.
8 „	E., moderate breeze, densely overcast. Continuous heavy rain.
Midn.	E.N.E., fresh veering to N. Heavy rain. N.E. swell rising.

January 22.

4 a.m.	N.E., strong breeze, with heavy rain. Considerable N.E. swell.
8 „	N., moderate gale. Some rain, high confused sea.
Noon.	N.N.W., moderate gale, bright sunshine, heavy N.W. sea.
2 p.m.	N.b.W., strong gale, very clear and bright. Sea rising, heavy bank of cumulus cloud in the west.
4 „	N.b.W., strong gale, sky covered with scud, looking very dirty, sea very heavy.
5 „	N.b.W, whole gale, densely overcast, with flying scud, sea rising.
6 „	N.b.W., whole gale, densely overcast, with flying scud, tremendous N.W. sea.
7 „	N.W.b.W., whole gale, driving masses of cloud, dangerous cross sea N.W. and W.
7.15 „	Barometer 28·56 ins. min. reading.
8 „	N.W., storm, terrific squalls. Sea a boiling mass of foam.
9 „	W.N.W., storm, terrific squalls. Tremendous cross sea. W. predominating (large quantities of phosphorescent matter in the sea).

January 22.

10 p.m. W., storm, terrific squalls. Tremendous cross sea. W. predominating.
11 „ W.S.W, whole gale, squalls not so violent, huge sea, but more regular, W.
12 „ W.S.W., stormy gale, clearing in the zenith, huge sea, but more regular, W.

January 23.

2 a.m. W.S.W., fresh gale, weather improving, very high true sea, W.S.W.
4 „ W.S.W., moderate gale, weather improving, very high true sea, W.S.W.
8 „ W.S.W., moderate gale. Some rain squalls. Sea moderating.
Noon. W.S.W., strong breeze and high sea, weather normal. Barometer 29·88 ins.

Bottom Temperature of Lakes.

The limnological work of recent years has frequently brought out the supposed fact that the bottom temperature is appreciably higher than that of intermediate layers. That this may—in some cases at least—be only an apparent character is shown by Baron von Aufsess in a note in *Petermann's Mitteilungen* (1905, No. 11).

Having found that the apparent rise in temperature may sometimes be explained as due to the increased pressure on the thermometer at greater depths, that observer lately carried out experiments with a specially constructed instrument, in which an ordinary minimum thermometer was enclosed in a stout glass tube, partially, but not wholly, filled with water before being sealed up. The water has the effect of accelerating the adjustment of the internal temperature to that of the water outside, while the air-space is necessary as a further safeguard against the influence of pressure at great depths. By taking a series of temperatures with this instrument and with an ordinary thermometer simultaneously, Baron von Aufsess found that at depths between 100 and 200 metres (330-660 feet), the difference might amount to as much as half a degree Centigrade (0°·9 Fahr.), and that when allowance had been made for this, no general excess of temperature was observable in the bottom layer. Where such does exist (after the necessary correction), he is inclined to attribute it to local causes, such as springs, or to suppose that the position of the upper and lower observations may not exactly correspond, owing to the drifting of the boat. It does not seem possible to apply any constant correction on the score of the influence of pressure, and the use of some such appliance as has been described seems necessary to avoid error, though care is needed to allow sufficient time for the equalisation of the internal with the external temperature, which probably involves from twenty minutes to half an hour.—*Geographical Journal*, April, 1906.

Hailstorm in the Gulf of Mexico, March 18, 1906.

The following communication has been received by the Meteorological Office from Mr. R. G. Bindley, the second officer on the s.s. *Jamaican* :—

During our passage across the Gulf of Mexico, on the night of March 17th and morning of the 18th, we experienced a thunderstorm of exceeding violence, and during the height of the storm a heavy hail squall crossed the vessel.

At 8 p.m. the wind was fresh from the east (true); the sky was overcast with strato-cumulus clouds, and a slight haze existed; occasionally a flash of sheet lightning was seen.

At 9·0 p.m. the haze grew slightly denser (being able to see about two miles), and the clouds were broken in places so that we could discern the stars at intervals; this state continued until 11.30 p.m., it was then noticed that the electric storm was advancing towards us, the "sheet" lightning was flashing

more frequently, and the distant rumble of thunder could be heard, the sky had again become completely overcast, occasional heavy showers of rain having begun to fall.

At midnight the "sheet" lightning was almost one continuous flash, only having a second duration between, and occasionally lighting the sky vividly for three or four minutes.

At 0·15 a.m. the first flash of fork lightning was observed in the south-east, and rapidly approaching the ship, crossed over us about 0·35 a.m.

Between 0·35 and 0·45 a.m. a most severe and dangerous hail squall crossed the ship. Its approach was heralded by the loud hissing sound generally preceding these heavy squalls, caused by the "stones" striking the water. When the squall reached the ship the "stones" were observed to be about the size of a walnut, but in the centre of the squall the hailstones were lumps of ice, equivalent in size to a large orange. Some afterwards picked up were found to be 2½ inches in diameter.

During this squall the ship was stopped, the officer of the watch and man at the wheel being compelled to take shelter.

The first officer sustained a severe bruise, caused by a stone striking him on the back of the neck; the helmsman received a scalp wound from the same cause.

The stones fell with such force as to dent the binnacles in several places, and chip the paint off the rails and other painted surfaces. During the night the barometer stood steady at 30·03 (corrected for error), and the thermometer at 0.30 a.m. was 64°, the temperature of the sea surface being 65°.

After the hail squall heavy rain set in for four hours, when the weather cleared generally.

The exact position of the ship during the squall was:—latitude 28°48′ N., longitude 93°47′ W.

Temperature Observations at Zi-Ka-Wei, 1873-1903.

The Meteorological Observatory at Zi-Ka-Wei, near Shanghai, China, has recently published a paper by the Rev. J. de Moidrey, S.J., on the "Reduction of the Temperature Observations, 1873-1903."

The tables give the daily maximum, minimum, and mean temperature, together with the daily range for each day of the period under discussion.

The following table gives the monthly summary for the 31 years:—

Months.	Extremes.		Means.			
	Max.	Min.	Max.	Min.	Range.	Mean.
	°	°	°	°	°	°
January	70·2	10·2	44·8	31·5	13·3	37·2
February	78·4	16·9	46·8	32·3	14·5	39·0
March	82·4	21·9	54·7	39·7	15·0	46·2
April	91·4	29·7	65·8	49·3	16·5	56·3
May	96·3	37·4	75·6	58·3	17·3	65·5
June	100·4	50·9	82·2	67·1	15·1	73·2
July	102·0	60·6	89·6	74·7	14·9	80·4
August	102·9	61·0	89·8	74·5	15·3	80·2
September	99·9	44·2	82·2	66·6	15·6	72·7
October	89·8	34·0	73·0	55·9	17·1	63·3
November	79·7	23·7	61·3	44·4	16·9	51·8
December	73·0	14·4	50·7	34·7	16·0	41·9
Year	102·9	10·2	68·0	52·4	15·6	59·0

Rainfall in Fiji, 1905.

Mr. R. L. Holmes has forwarded the following record of rainfall taken at Delanasau, Bua, Fiji, in 1905. Latitude 16° 38′ S., longitude, 178° 37′ E.; height above sea-level 71 feet; distance from sea 1 mile.

1905	Rain-fall.	Days of rain.	1905.	Rain-fall.	Days of rain.
	ins.			ins.	
January . .	9·91	18	July . .	1·67	7
February . .	10·60	14	August . .	1·51	10
March . . .	16·66	17	September . .	0·07	1
April . . .	2·31	7	October . .	2·24	3
May . . .	0·78	7	November . .	0·52	2
June . . .	0·72	8	December . .	3·87	10

The total rainfall, 50·86 ins., is the lowest yearly fall yet registered here. The average rainfall during the last ten years shows a great falling off compared with the previous term. Thus the average fall during 10 years ending 1905 was 73·69 ins., compared with 99·71 ins., the average fall during the 15 years ending 1895. The mean fall during the whole 35 years was 92·27 ins.

The year 1905 was remarkable for a very severe drought during the last nine months, which prevailed more or less over all Fiji. During the nine months nearly, to December 22, only 10·34 ins. fell here. In the last week of December 3·35 ins. fell, and in the first three days of January 2·78 ins. more, thus breaking the drought, but not in the decisive manner that occurred in Suva, where, according to the *Fiji Times*, a "torrential fall of half a foot" fell on December 20. A somewhat similar drought occurred here in 1877, when, in eight months ending December 31, only 12·50 ins. fell, but the early months of that year were very wet, 68·03 ins. falling in four months. During 14 months, ending October 11, 1878, only 43·49 ins. fell; but the planting season, then begun, was well supplied with moisture. So that the total fall named in each year may be very misleading so far as effect on vegetation is concerned.

On July 10, 1905, the exposed thermometer on the grass read 48°·4; and the minimum in the screen on verandah 56°·0.

On November 28 the dry and wet thermometers in the screen read 94°·0 and 73°·2, a difference of 20°·8. The dew-point was 60°·7; and the relative humidity, 33 per cent. The latter is much the lowest I have ever registered here.

The highest temperature in the shade was 96°·5 or 2° below the maximum shade temperature in 35 years. The mean temperature in the shade for 15 years was 79°·0, or 5° below the mean temperature of Queensland.

On July 3, at 3 p.m., there was a smart earthquake shock.

I have received from Mr. G. C. Barratt, the manager of the large tea and cocoa estate at Wainunu, 5 miles inland, particulars of the rainfall there during the last 26 years. Wainunu river lies about 25 miles from here on the south side of this island. Mr. Barratt has very kindly sent me the statistics that are most interesting and valuable. As so often remarked, the south coast is exposed to the moisture-laden South-east Trades, which when striking the land and rising over the hills deposit an immense amount of moisture. The average rainfall in 25 years was 151·70 ins. The heaviest fall in one year was 232·70 ins. in 1894, and the least fall was 100·21 ins. in 1884.

Yet even Mr. Barratt complained of insufficient moisture during the last four months of 1905. Insufficient, that is, for certain work on the tea estate, and to meet the requirements of the cocoa trees, of which there are now 10,000 in all stages of growth. The rainfall there during the last two years was as follows:—

	1904. ins.	1905. ins.		1904. ins.	1905. ins.
January . .	28·43	21·16	July . . .	1·72	9·77
February . .	21·81	24·47	August . .	10·02	5·84
March . .	15·78	15·02	September . .	7·84	nil
April . . .	14·75	12·33	October . .	15·57	4·10
May . . .	10·86	5·16	November . .	2·41	1·36
June . . .	11·18	3·95	December . .	19·68	8·11
			Total .	160·05	111·27

Climatology of South Africa.

At the recent Meeting of the British Association at Cape Town, Mr. C. Stewart, the Secretary of the Meteorological Commission, Cape Colony, read a paper on the "Climatology of South Africa," of which the following is an abstract :—

South Africa consisted essentially of a series of plateaux, increasing in elevation from the south to the interior—(1) Coast plateaux, (2) Southern or Little Karroo, (3) Central or Great Karroo, (4) Northern Karroo, or more properly the High Veld. These plateaux were most distinctly marked in a section from north to south through the centre of the country, but were not so apparent in the east and west, where they were reduced to mere terraces.

Temperature.—One of the most remarkable features in connection with temperature was the great uniformity in mean annual temperature shown by stations differing widely as regards latitude and longitude—*e.g.* the Royal Observatory at Cape Town, Cradock, Bloemfontein, and Johannesburg had practically the same mean temperature of about 62°. This was due to decrease of temperature with increase of elevation above sea-level almost neutralising the increase of temperature which would otherwise occur with increased intensity of solar radiation due to a nearer approach to the equator.

A closer examination showed variations of temperature, especially along the coasts, diminishing from north to south along the west coast, from west to east along south coast, from south to north along east coast, due chiefly to the modifying influence of the cold Benguela current in the west, and the warm Mozambique current in the east. The extremes of mean temperature were at Diaa Head (2500 feet), part of Table Mountain in the Cape Peninsula, with 54°·7 ; and Tuli in Rhodesia in the Shashi valley (1750 feet), with an annual temperature of 72°·4.

The average temperature of 97 stations scattered over South Africa was 62°·8, or nearly the same as at Sydney, New South Wales. The mean temperature curve was at its maximum in February, fell rapidly till June, continued to fall slightly in July, then rose, with a peculiar flattening of the curve in September, to the maximum in February. The continued fall in the July mean temperature was closely associated with a peculiar and apparently regular cold spell about the middle of the month. The minimum for the year occurred on July 16 over the Cape Peninsula, and on July 17 at Kimberley. The flattening in September was associated with an increase in the cloud-curve which was coincident with the change of the prevalent wind direction from North-west in August to South in September.

Rainfall.—The curve for South Africa showed two maxima, one in November and one in March, the minimum occurring in July. A comparison of the thunderstorm distribution curve showed that the two maxima in the rain-curve were not coincident with the two maxima in the thunderstorm-curve, the maxima in the thunderstorm-curve occurring in February (month of maximum mean temperature) and falling till June, then rising again to the maximum in February, with a dip down in November. South Africa might be divided into three rainfall areas, according to its seasonal distribution : (1) winter rainfall area in

the west, (2) constant rains (small area) in south, and (3) summer rains in the east. Rain fell chiefly with North-west winds in Cape Town and the west generally, with South-west winds along the south coast, and with South-west and some North-east winds along the east coast. There was little evidence in support of the "South-east Rain" theory, which would apparently have to be abandoned as far as the coastal areas were concerned.

Berg Winds.—These were föhn-like winds experienced practically all along the coast, blowing from off the plateaux at right angles to the coast-line, being Easterly in the west, Northerly along the south coast, and North-westerly in the east. Those at Port Nolloth caused the winter temperature there to be higher than that at Ookiep (the reverse holding during the rest of the year), and actually delayed the occurrence of the minimum mean monthly temperature till August. They were clearly connected with the occurrence of secondaries, especially during autumn and the early spring.

Storms.—The storms visiting South Africa seemed to be closely connected with moving anticyclones, and assumed apparently and principally the forms of inverted V-depressions, as in Australia.

Sunshine.—The largest proportion of sunshine occurred in the Cape Peninsula in summer, and was lowest in winter; whereas at Kimberley, which was typical of the greater part of the central plateau-regions of Cape Colony, the largest proportion of sunshine occurred in the winter months, when the days were mostly bright and cloudless, although the night temperatures were frequently low (below freezing-point) and severe. This fact had an important bearing on the suitability of the Karroo for phthisical patients and other invalids.

Mean Temperature at Stockholm, 1756-1905.

Dr. H. E. Hamberg has recently communicated a paper to the Swedish Royal Academy dealing with the monthly and annual means of temperature, and also the extremes of monthly temperatures during the 150 years 1756-1905. The following is a brief summary of the results :—

Months.	Means.					Extremes.					
	Mean.	Highest	Year.	Lowest	Year.	Max.	Day.	Year.	Min.	Day.	Year.
	°	°		°		°			°		
January . .	25·0	36·3	1796	6·3	1814	50·9	20	1898	−25·6	20	1814
February . .	25·2	36·9	1822	8·2	1772	53·6	21, 22	1797, 1878	−22·0	7	1805
March . . .	28·8	40·3	1822	16·2	1789	59·0	28, 29	1890	−13·9	7	1792
April . . .	37·8	46·0	1803	29·8	1812, 1829	77·0	29	1802	− 7·6	3	1808
May . . .	48·0	55·8	1798	37·9	1867	84·2	25, 24	1811, 1889	20·3	13	1867
June . . .	58·2	64·0	1774, 1896	51·3	1865	90·9	28	1876	32·0	4	1891
July . . .	63·0	70·5	1855	55·2	1832	96·8	3	1811	39·7	17	1863
August . .	60·8	69·6	1846	53·6	1864	90·5	1	1807	35·6	15	1757
September .	53·2	60·1	1775	46·9	1877	84·2	15	1804	25·7	30	1763
October . .	43·5	51·3	1846	33·3	1880	68·0	4	1802	15·8	23	1880
November .	34·5	41·7	1772	23·0	1774	57·2	1, 6, 1	1801, 1899, 1902	− 0·4	30	1884
December .	28·2	38·1	1789	13·3	1788	51·8	27, 5, 6	1881, 1898	− 8·5	24	1876
Year . .	42·2	47·0	1822	37·8	1867	96·8	July 3	1811	−25·6	Jan. 20	1814

RECENT PUBLICATIONS.

Die Niederschläge in den Norddeutschen Stromgebieten. Im amtlichen Auftrage bearbeitet. Von Professor Dr. G. HELLMANN. In drei Bänden. Berlin, 1906. 8vo.

This work on the Rainfall in the North German River Basins consists of three volumes, containing in all 2138 pages. Dr. Hellmann gives the rainfall for all the months and years previous to 1890, for all the stations in the area for which he has been able to obtain any record. The total number of stations dealt with is 3983. This work is a most valuable contribution to rainfall data.

Meteorologische Zeitschrift.—Hann-Band zum Vierzigjahrigen Redaktionsjubiläum J. HANN'S *von Freunden und Kollegen Gewidmet.* Redigiert von Dr. J. M. PERNTER und Dr. G. HELLMANN. Braunschweig, 1906. 4to. 404 pp. and 5 pl.

This supplementary volume of the *Meteorologische Zeitschrift* has been published as a memorial of Dr. Hann's forty years' editorial connection with that publication.

The book contains papers specially written for it by over forty distinguished meteorologists in all parts of the world. The titles of the papers are given in the current list of *Meteorological Literature* (p. 244).

Monthly Meteorological Charts of the Indian Ocean (North of 15° *S. Latitude) and Red Sea.* Issued by the Meteorological Office. 30 in. × 22 in. Commencing May 1906.

This new series of charts gives the monthly average distribution of winds, currents, pressure, temperature of the air and the sea, selected examples of the tracks of cyclonic storms in the Bay of Bengal, Arabian Sea, and South Indian Ocean, and other information, collected by the Meteorological Office.

Some information about the storm and weather signals of Indian ports is given on the back of the charts.

The Beaufort Scale of Wind Force. Report of the Director of the Meteorological Office upon an inquiry into the relation between the estimates of Wind Force according to Admiral Beaufort's scale and the Velocities recorded by Anemometers belonging to the Office, with a Report upon certain points in connection with the inquiry by G. C. SIMPSON, *and Notes by* Sir G. H. DARWIN, W. H. DINES, *and* Commander CAMPBELL HEPWORTH. Published by the Authority of the Meteorological Committee. London, 1906. 4to. 54 pp. and 7 pl.

The equation $P = \cdot 0105\ B^3$ is suggested as a suitable expression for the relation between the Beaufort numbers and the corresponding pressure of wind. Suggestions are also made for identifying the appropriate Beaufort numbers at sea, on the coast, and at land stations.

Report of the Meteorological Council for the Year ending 31*st of March* 1905, *to the President and Council of the Royal Society.* London, 1906. 8vo. 227 pp. and 3 pl.

The control of the Meteorological Office was transferred to a new body on April 1, 1905, so this Report of the Meteorological Council, the 28th, is the last of the series made to the Royal Society. As this completes 50 years in the history of the assignment of a Parliamentary Grant for the meteorological service of the country, first made in 1854 to the Board of Trade and subse-

quently, since 1867, to the Meteorological Committee or the Meteorological Council in connection with the Royal Society, a short account of the operations of the Meteorological Office since its establishment in 1854 is appended to this Report.

The Life History of Surface Air Currents. A Study of the Surface Trajectories of Moving Air. By W. N. SHAW, Sc.D., F.R.S., and R. G. K. LEMPFERT, M.A. Published by the Authority of the Meteorological Committee. London, 1906. 4to. 107 pp. and 27 pl.

This work represents the discussion of the results obtained for the motion of air in the neighbourhood of the British Isles from a number of sets of charts specially drawn for intervals of one or two hours with the aid of observations or autographic records collected from all parts of the country; and for the motion of air over the Atlantic from the daily synchronous charts for 1882-3.

Part I. gives a general account of the investigation and the conclusions drawn from it as to the motion of air with reference to cyclonic depressions and anticyclones, the changes which take place in the pressure and temperature of air as it moves, and the relation of the surface motion of air to rainfall. Part II. gives the particulars for eight selected cases of depressions in the neighbourhood of the British Isles, viz.: two fast-travelling storms, one slow-travelling storm, two cases of the formation or development of cyclonic depressions, one curious case of a complete change in the direction of motion of a depression, one example of a V-shaped disturbance, and a sudden change in pressure and wind in illustration of the phenomena of line squalls. Part III. deals with the motion of air over the Atlantic, while in Part IV. some theoretical points are taken up.

The work includes upwards of 130 charts of pressure, rainfall, or trajectories of air, 4 diagrams of the distribution of weather with reference to the positions of lowest pressure, etc.

Transvaal Meteorological Department. Annual Reports for the Year ended 30th June 1905. Pretoria, 1906. Foolscap folio. 156 pp.

The headquarters of the Department are situated at the Government Observatory, near Johannesburg. The Observatory was first occupied in May 1905, and was formally opened by Lord Milner on January 17, 1905. Mr. R. T. A. Innes is the Director, and he has a staff of four assistants. The Government have sanctioned the appointment of a Chief Assistant, who will be trained in weather-forecasting at the Meteorological Office, London.

The Observatory acts as headquarters for some 290 meteorological stations in different parts of the Colony. Two stations are outside the Colony, viz. the Swiss Mission at Lourenzo Marques and Bedworth Farm, O.R.C.; the latter is on the south bank of the Vaal, and is surrounded on three sides by the Transvaal. All the observers are volunteers and do not get any remuneration for their services. In November 1904 the Rand Water Board handed over to the Department 31 rainfall stations established by the Vierfontein Syndicate, Ltd., together with more or less complete returns since 1896. Nearly all of these stations are in the Witwatersrand District. In the course of the year the General Manager of the C.S.A. Railways agreed to a suggestion that station-masters in the Colony should undertake the charge of rain-gauges. The advantages are twofold: it at once gave the Department a more regular distribution of rainfall stations, together with an assurance of continuity of observation.

With the exception of perhaps 50 rain-gauges and half-a-dozen barometers and thermometers, all the meteorological instruments in the Colony have been supplied by this Department. In the period under review there were at work

290 rain-gauges, 56 sets maximum and minimum thermometers, 46 hygrometers, 27 barometers, besides a few sunshine recorders, automatic rain-gauges, anemometers, radiation thermometers, etc. At the headquarters at the Observatory a very complete set of automatic instruments has been installed. As might be expected, breakages have all along been heavy: few barometers have survived transport away from the railway lines; two of Callendar's Electric Sunshine Recorders have arrived broken, a third is on order. The Observatory possesses one of Dr. Aitken's Dust-Counters, but it has not been in regular use. With these exceptions, records are available from all instruments.

All the instruments have either been verified at Kew or compared with standards at the Observatory. A lightning recorder was set up at the Observatory in March 1905; it gives a permanent record of the intensity and duration of thunderstorms.

Telegraphic or telephonic messages are received every morning from 30 stations in the Colony. Morning telegrams are exchanged with:—The Meteorological Commission, Cape Town; The Observatory, Durban; The Meteorological Observer, Bloemfontein; The Meteorological Observer, Salisbury.

The tables in the Report give the results of observations (chiefly rainfall) at the various stations in the Colony, and also full details at the Johannesburg Observatory, including hourly records of rainfall, temperature, relative humidity, atmospheric pressure, wind velocity and direction. All the values are in English measures, with the exception of the hourly values of atmospheric pressure, which are in millimetres. It is to be regretted that Mr. Innes has not also given these values in English measures.

The monthly results of various elements at the Johannesburg Observatory, which is 5960 feet above sea-level, for the twelve months July 1904 to June 1905, are given in the accompanying table:—

Months.	Temperature.			Relative Humidity.	Rainfall.		Evaporation.	Sunshine.
	Mean.	Extremes.			Amt.	Days.		
		Max.	Min.					
1904.	°	°	°	%	in.		in.	%
July	51·3	67·0	34·0	...	·02	1	6·89	95
August	54·9	76·9	32·5	36	·02	1	7·79	98
September	56·4	79·5	26·5	39	·13	2	8·96	82
October	61·8	82·5	37·8	48	·79	8	10·25	76
November	65·4	88·3	47·2	60	4·54	9	10·68	65
December	62·3	81·8	40·0	67	3·28	12	9·42	56
1905.								
January	65·7	81·2	51·5	74	3·28	17	7·94	60
February	64·0	80·7	46·8	80	3·15	17	6·10	45
March	61·3	80·4	42·0	76	3·42	14	6·10	55
April	61·2	74·8	44·4	65	1·54	9	6·05	81
May	54·9	71·2	30·0	48	·35	3	6·42	89
June	48·9	66·6	28·7	43	·00	0	5·71	92
Year (July-June)	59·0	88·3	26·5	...	20·52	93	92·31	74

METEOROLOGICAL LITERATURE.

The following titles of papers bearing on Meteorology have been selected from the contents of some of the periodicals and serials which have been received in the Library of the Royal Meteorological Society. This is not a complete list of all the published meteorological articles, but only shows those that appear to be of general interest.

For a full Bibliography the reader is referred to the *International Catalogue of Scientific Literature.*

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AN INSTRUMENT FOR TESTING AND ADJUSTING THE CAMPBELL-STOKES SUNSHINE RECORDER.

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[Read May 16, 1906.]

THE sunshine recorder devised by Mr. Campbell, and modified by Sir George Stokes, was adopted by the Meteorological Council for official use in 1879, and is now installed at many stations which supply information to the Meteorological Office.

It consists essentially of two parts :—

1. A glass ball which brings the sun's rays to a focus.

2. A metal bowl carrying cards to form a belt, approximately spherical, on which the image of the sun burns a record.

These two parts have to be adjusted so that

(*a*) The surface prepared to receive the record is approximately part of the focal sphere of the glass ball;

(*b*) The surface prepared for a certain day's record is traversed by the sun's image on that day; and

(*c*) The image of the sun falls at set times on definite lines marked on the prepared surface.

By referring to Sir George Stokes' "Description of the Card Supporter for Sunshine Recorders" in the *Quarterly Journal of the Meteorological Society*, vol. 6, p. 83, it will be seen that for these adjustments to be correct with a standard instrument the following conditions must be satisfied :—

(*a*) Each card must be so adjusted that its centre line is at all points 2·88 ins. from the centre of the glass ball.[1]

[1] The precise distance 2·88 ins. is intended to place the cards a little beyond the geometrical focus for parallel rays of a 4-inch sphere made of a certain kind of glass, that being the distance selected by Sir G. Stokes as giving the most satisfactory burn.

(*b*) The plane cutting the equinoctial card along its central line must pass through the centre of the ball, and be inclined to the vertical at an angle equal to that of the latitude of the place at which the instrument is to be used.

(*c*) The lines drawn in that plane from the centre of the sphere to the middle points of the 6 a.m. and 6 p.m. marks on the equinoctial card must be horizontal and point east and west respectively; or, in other words, the line joining 6 a.m. and 6 p.m. centres on the equinoctial card must be horizontal, pass through the centre of the sphere, and be directed due east and west.

In a paper before the Royal Meteorological Society in 1900 Mr. R. H. Curtis[1] proposed modifications of the mounting of the bowl and of the sphere which provide means for adjusting the inclination of the bowl and the position of the glass. These modifications were adopted by the Meteorological Council for instruments ordered by them.

Experience has shown the necessity of an instrument for testing the shape and dimensions of recorders as they are received in the Meteorological Office, and for verifying the adjustment of the recorders as installed at the stations. It is very desirable that the adjustment of a sunshine recorder should be examined from time to time, and an Inspector is supposed to do this. But it is not at all easy by mere inspection or simple measurements with ordinary measuring instruments to check the adjustment of a sunshine recorder; nor is it possible on a sunless day, without some special instrument, to check the orientation, and so the time-scale of the instrument.

The difficulty in carrying out the necessary tests without a special instrument arises principally from the fact that the positions of all the parts of the recorder must be referred to the optical centre of the glass ball. For suitably uniform glass this is also the geometrical centre of the sphere. It is inaccessible for purposes of measurement when the sphere is in position, and is entirely undefined when the sphere is removed.

The first step in designing an instrument for testing recorders is therefore to get some means of identifying, in a way that can be used practically, the centre of a 4-inch sphere placed in the pedestal. This has been done in the instrument to be described, by making a metal cone of which the base is accurately turned to form a portion of a sphere of two inches radius and the point is at the exact centre of the spherical surface. Thus the point of the cone will always mark the position of the centre of the recording ball when the base of the cone is on the pedestal.

The second step is to provide a table with levelling screws that will carry a pair of adjustable points to be set level and form the ends of a line (the axial line) touching the middle points of the six o'clock marks at each end.

The third step is to provide a pointer that sweeps round in a plane passing through the axial line above mentioned.

The diameter of the sphere and its focal length for the sun's rays, which depends on the diameter and the kind of glass, should be determined before the instrument is issued. The determination is not included in the tests referred to in this paper. An opinion of the focussing can, however, be obtained from an inspection of the burn on an exposed card. The burn should be comparatively narrow—a wide burn, although it may penetrate the card and cause an impression slit in it, does not indicate intense sunshine merely, but bad focussing.

[1] *Quarterly Journal Roy. Met. Soc.* vol. 27, p. 63, 1901.

The fourth step is to provide the means for setting the plane in which the pointer moves at any angle to the horizontal table; in order to test the adjustment for latitude.

The fifth step is to provide the means for determining exactly with the aid of a map the orientation of the axial line, which should be exactly east and west.

Some attempts at defining the construction of the various parts of a suitable instrument had been made and a rough model constructed when Mr. Simpson joined the Meteorological Office as a volunteer assistant and took the matter up. The plan was altered in various particulars. Finally the Meteorological Council authorised the construction of an instrument from Mr. Simpson's drawings, and the apparatus was made under his supervision by Mr. P. Adie. The following is a detailed description:—

A Table T (see Figs. 1-4) is supported on three screw legs, L_1 L_2 and L_3, so that its height can be adjusted. Under the table two bearings B_1 and B_2 are fixed, in which the spindles S_1 and S_2 turn. Into the ends of S_1 and S_2 two pointed rods P_1 and P_2, the length of which can be adjusted, are fixed. The spindles S_1 and S_2 are connected together by a plate A. To this plate the arm R is attached by the pivot V, around which it can move parallel to the plate A. In the head of the pivot V,

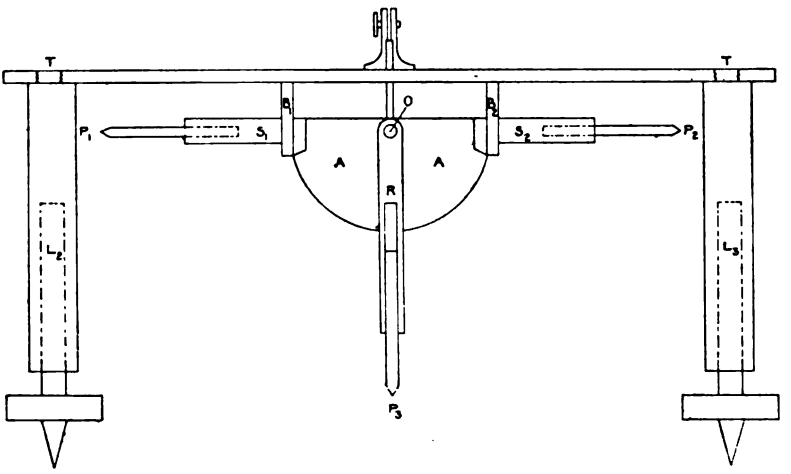

FIG. 1.

which is flush with the front surface of the arm, is a small dot O. Into the arm R is fitted an adjustable slide ending in the point P_3. The whole is so adjusted that the three points P_1 P_2 and P_3 and the dot O are in one plane; the dot (*i.e.* the centre of rotation of the arm R) is in the line joining P_1 and P_2. By means of the spindles S_1 and S_2 turning in the bearings B_1 and B_2, this plane is capable of rotation about the line P_1 O P_2, and the amount of its rotation can be read off on a scale C by means of the index Z. The plane can be clamped in any position by the clamp K.

On the top of the table are two spirit-levels, one parallel to the line

joining P_1 and P_2, and the other exactly at right angles to it. By means of the former the line joining P_1 and P_2 can be brought into the horizontal. The second level is so adjusted that when the bubble is in its middle

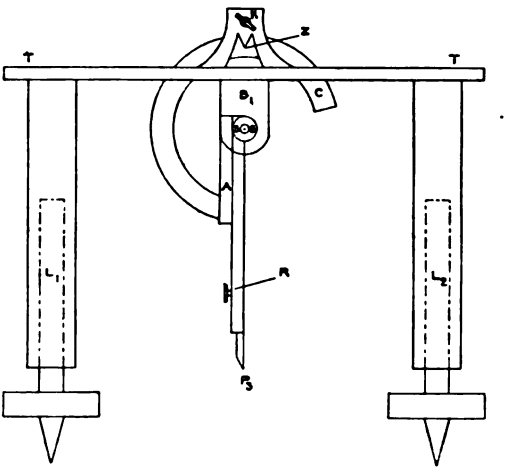

FIG. 2.

position, and the index Z is placed against the zero of the scale C, the plane containing P_1 P_2 P_3 and the dot O is exactly vertical, and when the index reads 90° the plane is horizontal.

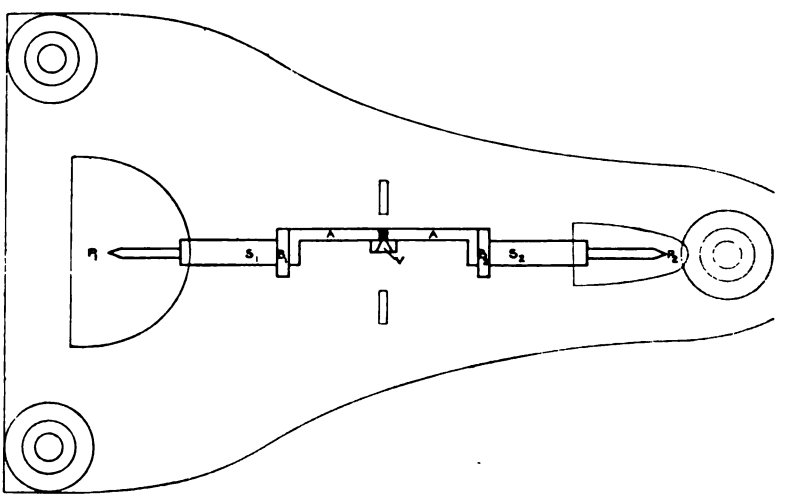

FIG. 3.

Thus when both these levels are in adjustment the line joining P_1 O P_2 is horizontal, and the plane P_1 O P_2 P_3 is inclined to the vertical at an angle indicated by the index Z.

It will be obvious that with such an arrangement, if the distance of the points P_1 P_2 and P_3 from O are all the same, the point P_3 will move

over part of the surface of a sphere having O for its centre and P_1 O P_2 for a diameter. Thus if the dot O could be placed in the position occupied by the centre of the glass globe of an accurately adjusted sunshine recorder, and the length O P_1, O P_2, and O P_3 all adjusted equal to 2·88 ins., then P_3 would always lie on the focal sphere, and so should touch each of the three cards along their centre lines, and nearly touch them at all other points. Also, if P_1 were placed against 6 a.m. on the equinoctial card, P_2 would touch the 6 p.m. point, because, as stated above, these two six o'clock points and the centre of the sphere are in the same straight line. This line would also be horizontal and directed due east and west. If the pointer P_3 were placed against the middle line on the equinoctial card, the plane containing P_1 P_2 P_3 and the dot

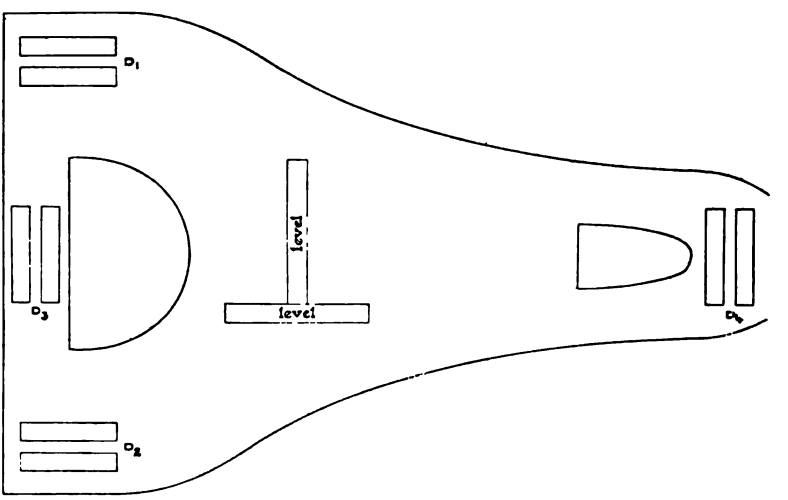

FIG. 4.

O would coincide with the plane cutting the equinoctial card along its middle line; and so the inclination of this plane relative to the vertical plane can be read off by means of the scale C and the pointer Z. As the recorder is supposed to be in perfect adjustment, this inclination would be found to be equal to the latitude of the place.

These principles can be used to put a new recorder into adjustment.

Let the points P_1 P_2 and P_3 be adjusted so that they are 2·88 ins. from the dot O, and clamp the scale C with the index indicating an angle equal to the latitude of the place at which the recorder is being used. Now place the table of the instrument over the recorder, and by means of the screw legs bring the points P_1 and P_2 into contact with the six o'clock marks of the equinoctial card, and the point P_3 into contact with the line drawn along the centre of the same card. Now pack up the base of the recorder until the bubbles of the two levels on the top of the table are brought into their central positions, and turn the whole until the line joining P_1 and P_2 points due east and west (the method of doing this will be described in detail later). The bowl is then in perfect adjustment, and the position which the centre of the ball must occupy is indicated by the dot O. It remains now to adjust the pedestal on which the ball is

placed, so that the ball will be in its correct position. This latter is done as follows :—The pedestal ends in a small cup in which the ball rests; a cone is turned so that it has a spherical base of the same radius as the glass ball, and a height equal to that radius, then the apex of the cone corresponds with the centre of the ball. If such a cone is placed on the pedestal its apex will always indicate the position which the centre of the ball would occupy. The position of the base of the cone can be moved on the pedestal as much as one pleases, without moving in the slightest the position of the apex. Such a cone has been turned in brass to the 2-inch radius corresponding to the glass balls in use with the recorders.

In order to adjust the position of the pedestal all that has to be done is to place the cone on the cup, and then move the pedestal until the point of the cone just touches the dot O. The pedestal is then screwed fast in this position, and the adjustment is made. On removing the instrument and the cone and replacing the ball on the cup the whole recorder is in accurate adjustment.

We next consider the method used for adjusting the line $P_1 P_2$ to be in an east and west direction.

The most obvious way of doing this is to place a compass on the top of the table and adjust thereby. The objection to this method is that the positions in which sunshine recorders are placed are often such that the proximity of iron makes the use of a compass quite impossible.

From the nature of the instrument a sunshine recorder must be placed in such a position that it has an open horizon to the east and west. It also often happens that it has an open horizon all round. This being so, it is nearly always possible to see from the position of the instrument some distant object the bearings of which can be obtained from an ordnance map. In order to make use of this fact without having recourse to a telescope and graduated scale a system of sights has been designed.

On the top of the table of the instrument four sets of grooves, D_1 D_2 D_3 and D_4, have been fixed. Into these grooves the sights fit. These are (1) a metal frame of brass, down the middle of which is fixed a horse-hair; and (2) an ivory scale carrying two sets of equidistant lines. If it is found that some distinctive object, say a factory chimney, a tree, or the corner of a house, lies more or less to the eastward of the position of the recorder, then the sight having the hair would be slipped in the groove D_3, and the one carrying the scale in the groove D_4 (their positions in the grooves are accurately fixed by means of stops). On an Ordnance map the distance of the object to the eastward and its distance north or south would then be measured. The latter of these measurements is then divided by the former, the result being expressed as a decimal fraction. On the ivory scale the divisions are each one-tenth of the distance between the hair and the scale, so that when the line $P_1 P_2$ is exactly due east and west, the hair, the distant object, and the number on the scale corresponding with the fraction are all in a straight line.

Thus all one has to do to adjust the instrument is to move it until the hair covers the distant object and the required division of the scale at the same time.

If the conspicuous object is to the west the sights are reversed; while if it is to the north or south the sights are placed in the grooves D_1 D_2 and the other scale used.

If two or three conspicuous objects are sighted the position of the recorder can be adjusted with great accuracy.

Method of using the Instrument.

(1) *To test a Standard Sunshine Recorder already in position.*

Set the points P_1 and P_2 so that they are 2·88 ins. from O. (The scales engraved on the pointers themselves are half-inches; this is in order that the distance between the 6 o'clock points can be measured by any convenient means, and each pointer drawn out to the number corresponding to that distance; the total distance between P_1 and P_2 will then be equal to the measured distance, and each point will be the correct distance from O.) Remove the ball from the pedestal, insert an equinoctial card in its proper grooves, and place the instrument over the bowl. Now adjust the screws L_1 and L_2 until the point P_1 is in contact with the 6 a.m. mark on the card, and the bubble of the north and south level is in its middle position. Now adjust the screw L_2 until the point P_2 is in contact with the 6 p.m. mark. If the recorder is level, then the bubble in the east and west level will also be in its middle position.

Now bring the point P_3 into contact with the middle line on the card and screw up the clamp K. If the recorder is set properly for latitude, then the index Z will point to the angle on the scale corresponding to the latitude of the place.

Now fasten the pointer P_3 and move the arm R about the pivot V. The point P_3 should then touch the card all along its middle line; if it does not it shows that the card is not a semicircle. The error may be due to a distortion of the bowl or of the card in the bowl.

Now by means of the sights measure the bearings of any convenient distant objects and compare them with the bearings as measured on an Ordnance map.

If all these adjustments are found to be correct, then it only remains to see if the ball is in its proper position. To do this, place the cone on the cup in the pedestal, then if the apex of the cone just touches the dot in the pivot this adjustment also is correct.

(2) *To adjust a Recorder.*

Set all three points P_1 P_2 and P_3 2·88 ins. from O. Set the index Z against the angle corresponding to the latitude of the place, and screw up the clamp K. Insert an equinoctial card in the bowl. Now place the instrument over the bowl, and by means of the levelling screws bring P_1 and P_2 into contact with the 6 o'clock points, and P_3 into contact with the middle line along the card. Now by means of the sights get the instrument approximately in its correct orientation; then pack up the base of the recorder until the bubbles in the two levels are in their middle positions. Now finally adjust the orientation, and then restore the level if it has changed. When the orientation and the levels are correct the base should be cemented in its position, care being taken not to disturb the setting.

When the cement has set, it only remains to adjust the pedestal. Place the cone on the cup, and then move the pedestal until the apex of the cone just touches the dot O; when the correct position of the pedestal has been found it should be fixed by tightening the adjusting screws.

DISCUSSION.

Mr. R. H. CURTIS said that, having been a good deal interested in sunshine recorders, he had naturally given some attention to the subject of testing their accuracy and adjustment. He thought the instrument which Dr. Shaw had described was an excellent one for ascertaining whether a recorder had been accurately constructed; but for general use in setting up a recorder in the meridian, when the help of the sun was not available, he thought the absence of a compass was a drawback which would often place it at a disadvantage. A six-inch Ordnance map was not always available at, say, a country station; and when it was, he thought, speaking from experience, that the finding of an object at once sufficiently distant and conspicuous for the purpose of orienting the recorder would sometimes be a little difficult. For that reason he had included an azimuth compass in an instrument he had suggested for the purpose, and which proceeded in some respects upon similar lines to that now shown. It was generally assumed by purchasers that when an instrument left the maker's shop it was in perfect order, and that at least such points as the cutting of the grooves to give the proper amount of overlap to the cards, and the size of the bowl with respect to the time-scale of the card, had been looked after. He was afraid that, as a matter of fact, such was not always the case, and therefore the necessity for careful testing of every instrument. If the bowl was too large for the time-scale or the card, the record as read from the card would be too great, and *vice versa*.

Mr. W. MARRIOTT said that the apparatus appeared to be a very nice instrument, and that Dr. Shaw and Mr. Simpson were to be commended for it. He hoped every inspector of sunshine recorders would be provided with such an instrument. He thought that the sun itself was the best guide in testing the recorder, as it was possible by this means to see if the spot of light was placed where it should be; but of course if the weather was dull or wet this method was out of the question, and then the new instrument would be of use. He noticed that nothing had been said about the glass ball, and assumed that it was supposed to be all right. It would, however, be very interesting to see if all balls gave similar results. He thought they should be tested like thermometers before being sent out to the observers, as it would tend to give greater uniformity of results. Unfortunately it was the tendency of some observers at the so-called health resorts to try and report as much sunshine as possible.

Mr. F. C. BAYARD drew attention to the glass balls, and said it was absolutely necessary that they should be made of the same constituent parts. The Greenwich and Regent's Park balls had both become corroded on the outside after about 10 years' use, and gave diminished records. He thought that the balls ought to be tested every few years to see if they were still giving accurate results, and that it would be advisable if some method of exchanging balls with the makers for testing purposes could be arranged.

Mr. W. ELLIS said that Dr. Shaw had done an excellent thing in contriving an instrument for the more complete testing of the Campbell-Stokes sunshine recorder; some improved plan for so doing could not but be useful, and he hoped to have an opportunity of examining the instrument. The sunshine recorder is really a little astronomical instrument, requiring, in its way, to

be adjusted with corresponding accuracy as regards level, and for latitude and meridional position. As concerns the latter, there is the method by compass and that by the sun. To these we have now a third method, as proposed by Dr. Shaw, rectification by reference to some convenient distant object given on an Ordnance map. The compass method would probably be the least accurate, independently of local attraction. The method by the sun requires sunshine and an accurate knowledge of local time. That described by Dr. Shaw is one that, given a convenient, sufficiently distant object, might be independently employed when the sun could not be seen: in thick wintry weather, however, both this method and that by the sun may be, for a time, impracticable.

Mr. R. H. CURTIS, referring to a remark of Mr. Bayard's respecting the reliability of the lenses, thought care should be taken not to raise doubts which were not really justified. In two cases lenses had been known to have become deteriorated by exposure to the action of a more or less impure atmosphere; but both these lenses were from the same maker in France, and as both were bought at the same time it was probable they were from the same "metal," which was unlike that used for the lenses made by Messrs. Chance. But those cases stood alone, and, speaking from a very wide experience, he had never heard of any others. He had frequently compared the records of two instruments placed side by side, in one of which a new lens was used against another of many years' exposure; but in every case, other things being equal, the records were the same, and in some instances they were practically indistinguishable from each other. In view of the increasing use of sunshine recorders, he thought this fact ought to be known.

Dr. W. N. SHAW, in reply, said that the sunshine recorder was really a delicate astronomical instrument. Some of its adjustments required to be very exact, while with others a certain amount of laxity was allowable. The sun was a very good test for adjusting the recorder for azimuth, when all the other adjustments had been made. But suppose the level and the latitude were also out, other apparatus would be necessary. There was an enormous reserve of burning power in the sunshine ball, and if observers would occasionally test their recorders by burning a record of from 1 to 5 seconds' duration they would find out this power for themselves. Mr. Inwards's idea of a compass-joint would deal with the correctness of the distance from the centre of the frame, but not with the question of adjustment for level and latitude.

The PRESIDENT (Mr. R. BENTLEY) said he was sure they all much appreciated the work of Dr. Shaw and Mr. Simpson in designing this new instrument, which he regarded as a very useful one, for the verification of newly placed recorders or those just received from the makers. The Campbell-Stokes recorder gives the duration of sunshine; and perhaps some day the intensity might also be shown mechanically, though at present it could be estimated by instrumental readings *in vacuo*. In the comparison of returns from different parts of England allowance had frequently to be made for the position of the instruments, and he would like to suggest that when each station was inspected note should be taken of the amount of horizon available at each station, and that this should be prefixed to the monthly readings in figures. A perfect exposure would be shown as 360°, and any one referring to the list would then see at a glance if any record was liable to be defective.

Rainfall Terminology.

Dr. H. R. Mill, in his *British Rainfall for* 1905, says:—"It is very important in all scientific work that every definite idea should be expressed by an equally definite word or *term*, which is not used for any other purpose, or which can at least be readily recognised whenever it is appropriated to a narrower use than that customary in ordinary language. Such terms are often derived from the Greek, and an example of this is found in the word *isohyetal* which is applied to a line passing through places having equal rainfall on a map. It so happens that English words have been found quite good enough to express most of the definite ideas with regard to rainfall work, though their meanings have to be restricted for the purpose. Thus the convenient expression *Drought* has been given precision by association with an adjective in the form of *Absolute Drought* for a succession of more than 14 days without recorded rain, and *Partial Drought* for a succession of more than 28 days with a very small average rainfall per day. I wished to find an equally simple term for a succession of more than 14 days, on each of which rain fell, and in the hope of lighting upon some good but obsolete English word I applied to the distinguished lexicographer, Dr. J. A. H. Murray, of Oxford, the highest authority on the subject. He most kindly went fully into the subject, but could find no word bearing the same relation to 'wet' as *drought* does to 'dry,' unless the word *weet* would serve. To *weet*, however, despite a certain attractiveness, there is the disadvantage of an undignified colloquial use in a certain part of the British Isles with reference to liquid refreshments, and it seemed better to adopt Dr. Murray's endorsement of my provisional expression 'rainy spell,' though I gladly accept his suggestion to shorten it to *Rain spell*. This necessitated another desirable change, which had already been made by other meteorologists, in the use of *Rain day* to denote a day on which at least ·01 in. of rain is recorded, instead of the 'rainy day' hitherto referred to in these pages.

"Another set of words which seemed to require setting in order are *Mean* and *Average*. The two have long been used in these pages as interchangeable, but I have now resolved to try to use each in a definite sense. I accordingly use the word *mean* to express the sum of any number of values divided by that number; that is to say, if a column of twelve figures adds up to 120, the mean of that column would be 10. It is thus used in a wide and unrestricted sense. But *average* I think it desirable to restrict to the mean of rainfall figures taken over a range of time, and thus speak, for instance, of the *average rainfall* of a place for ten years. A third word then became necessary to designate the mean rainfall of a number of places at the same time, and for this I have found the word *general* to be useful and satisfactory. Thus while the word *mean* is left free for use with any set of figures that may have to be added up and divided, the average rainfall at Camden Square denotes the mean of a number of years' rainfall at that station, while the general rainfall of the county of London in 1905 means the whole volume of rain which fell upon the county of London divided by the area, *i.e.* the mean of all the rainfall records for the year in the county, supposing that the stations yielding them were uniformly distributed. The average general rainfall of the British Isles is the mean of the general rainfall for a series of years. Any one who has endeavoured to convey the facts regarding the variations of rainfall at stations, or over areas at one time or various times, will understand the difficulties I have endeavoured to meet. I am not wedded to any of these words, and will gratefully accept better if they are suggested."

The term "Rain spell" is an appropriate one to indicate a period of more than 14 consecutive days, every one of which is a "rain day." The other terms mentioned by Dr. Mill are likely to be useful and satisfactory. They are in agreement with the definitions given in the *Hints to Meteorological Observers*.

THE DEVELOPMENT AND PROGRESS OF THE LINE-SQUALL OF FEBRUARY 8, 1906.

By R. G. K. LEMPFERT, M.A., F.R.Met.Soc., Superintendent of Statistics of the Meteorological Office.

[Read May 16, 1906.]

On the afternoon of February 8, 1906, there occurred in London a violent thunderstorm accompanied by a heavy fall of hail. The reports which reached the Meteorological Office on the following morning showed that the phenomenon had been widespread, and I was instructed by the Director to undertake a detailed study of the meteorological situation of that day. A circular letter was accordingly sent round to observers in connection with the Office and to other persons who were known to possess self-recording instruments, asking for the loan of the traces for the day. Further assistance was given by Dr. Mill, who kindly inserted a letter in *Symons' Meteorological Magazine*. An appeal addressed to the Scottish Meteorological Society put me in possession of a number of records from the northern portion of the country, from which information would otherwise have been very scarce. M. Durand Gréville kindly supplied tracings of the records taken in Paris at the Observatoire de Montsouris. Including the returns which are received at the Meteorological Office in the ordinary course I have had at my disposal records from over one hundred stations, and I should like here to express my indebtedness to all who have contributed to my store of information.

A rapid review of the curves soon showed that changes which could be brought into connection with the severe disturbance which occurred over England in the afternoon took place throughout the British Isles, and it is not unlikely that if the inquiry were extended a large portion of the Continent would also be found to have been affected. The records from Utrecht, Brussels, and Paris all show changes similar to those which occurred over England.

As was expected, the disturbance proved to be a "Line Squall" of the type with which the researches of Köppen,[1] Durand Gréville,[2] Mossman,[3] and others, and the investigation of thunderstorms, have rendered us familiar. In Fig. 1, I have plotted the times at which the changes occurred at the various stations, and then drawn the isochronous lines, which enable us to follow the progress of the storm across the country. The lines all lie in a south-west to north-east direction. The squall was first noted at Stornoway at 12.30 a.m. on the 8th, and the last station in England to feel its effects was Hastings, which it passed at about 4 p.m. The rate of progress appears to have been tolerably uniform, though it increased somewhat in the south-east of the country, where the thunder and hailstorms were most intense. The average speed of advance of the line of squall works out at about 38 miles per hour. Thus a traveller from York to London leaving the former place at 11.15 a.m.

[1] *Annalen der Hydrographie*, 1882, vol. x. pp. 595 and 714.
[2] *Comptes Rendus*, vol. cxvii.
[3] *Journal of the Scottish Met. Soc.*, Third Series, vol. ix. p. 237.

would have had the unique experience of accomplishing the whole journey in a thunderstorm, if the train service had been suitable.

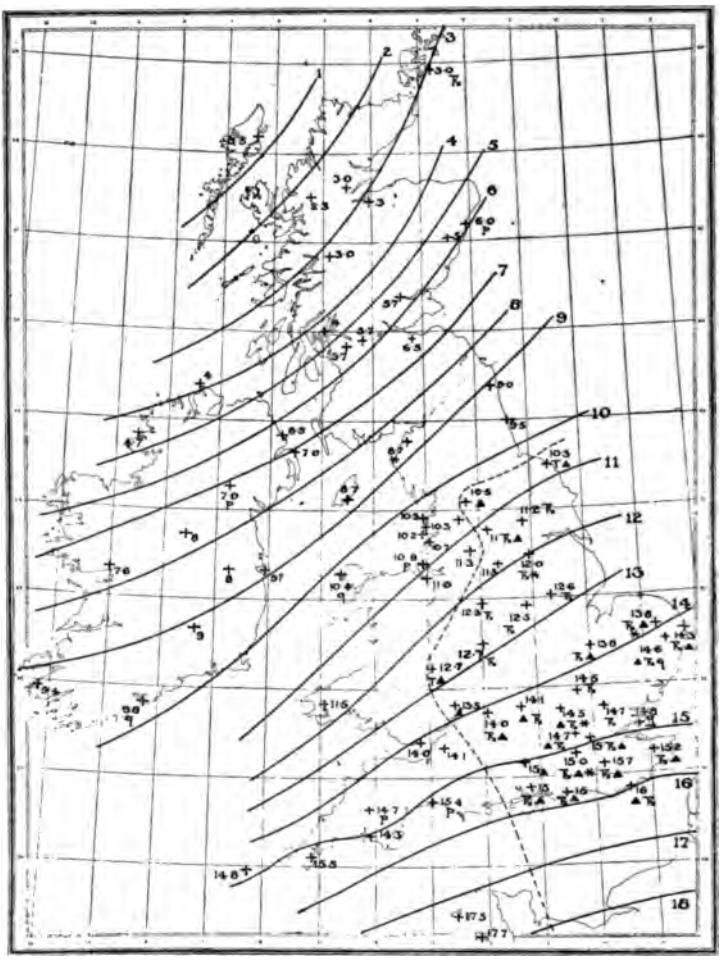

FIG. 1.—Times of occurrence of sudden meteorological changes, and isochronous lines showing the advance of the squall. The hours are numbered consecutively from 1 to 18, starting at 1 a.m., February 8, and the minutes are expressed as decimal fractions of an hour. Hail and thunderstorms occurred in the region to the east of the dotted line.

The character of the changes produced at an individual station by the disturbance when at its maximum intensity is shown in the records from the Kew Observatory, which are reproduced in Fig. 2. For the remaining stations I have endeavoured to give a short summary in tabular form (see Tables I. to VII.). The changes were exceedingly sharp and characteristic at most English stations; but over Scotland, Ireland, Wales, and also in the south-west of England, they were less intense. The following notes on the behaviour of the individual elements in different parts of the country draw attention to the main points of difference.

Wind Direction.—The anemograms all show a change in wind direction from about South-west to North-west. At the English stations the

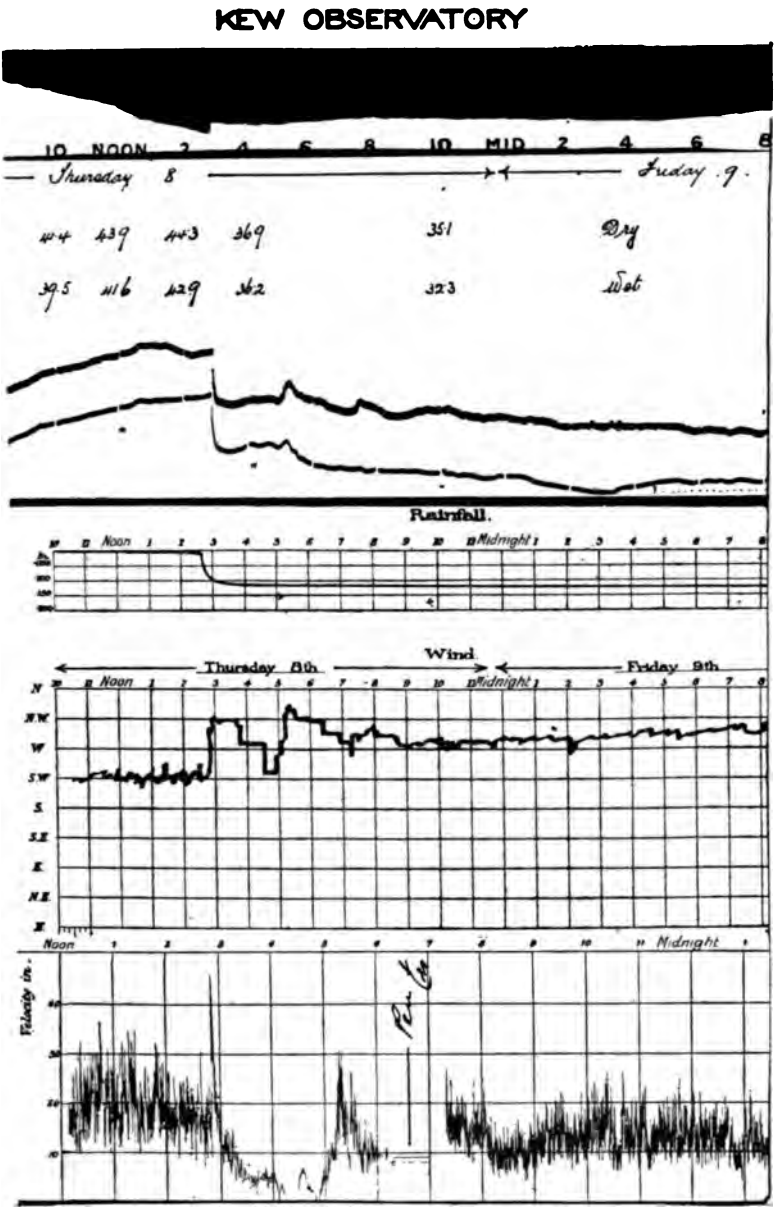

FIG. 2.—Records from Kew Observatory.

transition was as a rule sudden, as at Kew, but in Scotland and Ireland it generally required from 30 to 90 minutes for its completion. The

TABLE I.—Stations supplying Continuous Records of all Elements.

[*Note.*—In this and the following Tables the Hours have been expressed by Numbers 1 to 24, commencing at 1 a.m. Minutes have been reduced to Decimal Fractions of an Hour.]

Station.	Observer.	Time of passage of Squall.	Barogram.	Thermogram.	Anemogram.	Precipitation and Remarks.
Paisley . .	The Coats Observatory	5·7	Rapid fall checked suddenly.	Attained a maximum and commenced to fall briskly.	Commenced to veer from WSW. to NW., change completed in half an hour; strong gale.	Rain midnight till 7 a.m.
Glasgow .	Prof. L. Becker, for the Meteorological Office.	5·7	Rapid fall checked suddenly.	Commenced to fall from a maximum of 45°; became very irregular.	Commenced to veer from SW. to W., change complete in 1½ hour; velocity 25 m. p. h.; no conspicuous changes.	Rain ceased temporarily.
Aberdeen .	Prof. C. Niven, F.R.S., for the Meteorological Office.	6·0	Changes inconspicuous; rate of fall checked about 5 a.m.	Commenced to fall suddenly from maximum 42°; became irregular.	Veered slowly from SSW. to WSW. from 4 to 6 a.m.; sudden veer to WNW. at 6 a.m.; no conspicuous change of velocity.	Rain-shower ·05 in.
Valencia .	J. Cullum, F.R.Met. Soc., for the Meteorological Office.	9·4	Ceased falling at 8 a.m.; slight sudden rise at 9·4 hrs.	Fell suddenly from 49° to 47°; became very irregular.	Sudden veer from SW. to NW.; velocity 25 m. p. h.; no sudden change.	Showers at 8·3 and 9·0 a.m.
Southport .	J. Baxendell, F.R.Met. Soc., for the Corporation.	10·7	Fall ceased; sudden rise ·04 in.	Fell suddenly 44° to 39°.	Sudden veer from SW. by W. to NW. by W.; squall 59 m. p. h., followed by drop to 30 m. p. h.	Very heavy rainfall, ·13 in. in quarter of an hour, but humidity decreased from 99 to 78 per cent.
Stonyhurst .	Rev. W. Sidgreaves, S.J., for the Meteorological Office.	10·7	Fall ceased; sudden rise ·05 in.	Fell suddenly 43° to 37°.	Sudden veer from WSW. to WNW.; velocity 25 m. p. h.	...
Berkhamsted .	E. Mawley, F.R.Met. Soc.	14·5	Fall ceased; sudden rise ·04 in.	Fell suddenly 47° to 39°.	Veered suddenly from WSW. to NW.; squall then decreased to light breeze.	Shower ·12 in.; thunderstorm, hail, snow.
Oxford . .	The Radcliffe Observatory, Dr. A. A. Rambaut, F.R.S.	14·1	Fall ceased; sudden rise ·04 in.	Fell suddenly 47° to 39°.	Sudden veer from WSW. to NW.; squall, then decreased to light breeze.	Shower ·13 in.; thunderstorm, hail.
Kew . .	C. Chree, F.R.S., for the Meteorological Office.	14·7	Fall ceased; sudden rise ·09 in.	Fell suddenly 44° to 37°.	Sudden veer from SW. to NW.; squall 48 m. p. h., then almost calm.	Shower ·11 in.; thunderstorm, hail, snow.
Canterbury .	A. Lander . . .	15·2	Fall ceased; sudden rise ·09 in.	Fell suddenly 46° to 34°.	Sudden veer from SW. to NW.; heavy squall, followed by great decrease of wind.	Shower ·26 in.; thunderstorm, snow; building struck by lightning.
Falmouth .	E. Kitto, F.R.Met.Soc., for the Meteorological Office.	15·5	Fall ceased; sudden rise less than ·005 in.	Fell rapidly from 48° to 44°.	Sudden veer from W. to NNW.; squall 57 m. p. h., followed by decrease to 30 m. p. h.	Shower 2.30 p.m.; no rain, hail, or thunder at time of change of wind.

TABLE I.—STATIONS SUPPLYING CONTINUOUS RECORDS OF ALL ELEMENTS.—*continued.*

STATION.	Authority.	Time of passage of Squall.	Barogram.	Thermogram.	Anemogram.	Precipitation and Remarks.
Paris . . (Montsouris)	Supplied by M. Durand Gréville.	20·3	Fall ceased 7.45 p.m.; rapid rise till 9 p.m. of ·05 in., then steady.	Brisk fall commenced at 8.15.	Veered from SW. to NW. from 7 to 8.30 p.m.; squall 35 m. p.h. at 8.36 p.m.	Rain and snow 6.45 till 9.45 p.m.
Brussels . .	Belgian D.W.R. .	17·8	Fall ceased; sudden rise ·05 in.	Brisk fall commenced.	SSW., 15 m. in the hour at 4 p.m.; SW., 21 m. in the hour at 6 p.m.; W., 12 m. in the hour at 8 p.m.	Thunderstorm, hail, snow.
Utrecht .	Dutch D.W.R. .	16·4	Fall checked; sudden rise ·01 in.	Sudden fall . .	SW., 13 m. in the hour at 4 p.m.; WNW., 7 m. in the hour at 6 p.m.	Heavy shower.
Hamburg. .	D. W. R. of the Deutsche Seewarte.	...	Ceased falling about 2 a.m. on 9th.	No sudden change.	WSW. in direction till 10 a.m. on 9th.	...

TABLE II.—STATIONS SUPPLYING BAROGRAMS AND THERMOGRAMS (and in some cases Pluviograms).

STATION.	Observer.	Time of passage of Squall.	Barogram.	Thermogram.	Precipitation and Remarks.
Clongowes Wood College	Rev. S. P. Hackett, S.J.	8	Fall ceased . .	Temp. commenced to fall about 10; time-scale very doubtful.	No thunder or hail.
Hodsock . . .	H. Mellish, J.P., F.R. Met.Soc.	12·0	Fall ceased; sudden rise 0·5 in.	Sudden fall 45° to 37° . .	Shower ·15 in.; thunderstorm, snow.
Chatsworth . . .	The Duke of Devonshire.	?	Fall ceased; sudden rise 0·3 in.	Sudden fall 43° to 37° . .	...
Geldeston . . .	E. T. Dowson, F.R.Met. Soc.	14·6	Fall ceased; large rise.	Sudden fall 41° to 31° . .	Thunderstorm, heavy hail and squalls, snow.
Guernsey . . .	A. Collinette . . .	17·5	Ceased falling; no sudden change.	Fell 47° to 44°	No thunder or hail.
Jersey	The Harbour Master .	17·7	Fall ceased; sudden rise ·02 in.	Little change	No thunder or hail.

line of squall was thus a line of separation between two air currents from directions approximately at right angles to each other.

Wind velocity.—The changes in wind velocity were more varied. The squall itself can be traced in most of the curves, but it was not universal. Thus at Oxshott, in Surrey, the pressure-tube anemometer showed no sign of any sudden increase of wind; a brisk current from the South-west gave place suddenly to light airs from the North-west. From the Kew curves we might be led to suppose that the velocity in the squall was approximately of the same magnitude as the velocity of the squall line, but this generalisation is not borne out by the records from other stations. For instance, at Bidston and Shoeburyness the velocity in the squall reached 80 miles per hour—about double the velocity of the line of squall. In the east of both England and Scotland the speed of the wind in the North-westerly current in the rear of the squall was much less than that in the South-westerly wind in front of it, a fact which is very obvious in the tabulations of hourly values. In the south-eastern districts, the wind after the squall had passed sank to a light air. In the west, on the other hand, strong winds prevailed both in front and rear of the squall; at Holyhead the velocity was even greater after its passage than before it.

Pressure.—The barograms all have one feature in common, viz. that a rapid fall of the barometer was interrupted by a state of almost steady barometer. The sudden increase of pressure, which forms such a characteristic feature of the curve from Kew, occurred at all English stations east of the meridian 3° W. in varying intensity. At most Scottish stations the curves of falling and steady barometer make sharp angles with one another, so that it was easy to fix the time of passage of the disturbance, but a sudden increase of pressure was not shown as a rule. It is, however, interesting to note that at both Glencarron and Strathpeffer Spa, which were passed at about 3 a.m., the barograms show sudden upward movements similar to those recorded over England. At the same hour thunder was heard at Deerness in the Orkney Islands (though it must be mentioned that the observer is not quite certain about the date). It appears as though the disturbance had increased temporarily in intensity about this time. In the traces from Ireland the angle between the falling and the steady portions of the curves was, as a rule, smoothed off, so that it was often difficult to fix the time of passage of the disturbance with precision.

Temperature.—The thermograms in all cases present a sharp contrast between the exceedingly steady conditions of temperature which prevailed in the South-westerly air current and the remarkably unsteady conditions of the cold North-westerly wind, so that they afford a ready means of fixing the time of passage of the "line." The amount and rapidity of the first fall varied at different places; it was greatest in the south-east of England.

Precipitation and Weather Phenomena.—In Scotland and Ireland rain commenced several hours before the change of wind, and ceased shortly after it occurred. In the southern portion of England rain did not fall before the time of the squall. The amount of precipitation which

TABLE III.—STATIONS SUPPLYING BAROGRAMS, ANEMOGRAMS, AND IN SOME CASES PLUVIOGRAMS.

STATION.	Observer.	Time of passage of Squall.	Barogram.	Anemogram.	Precipitation and Remarks.
Edinburgh .	The Astronomer Royal for Scotland.	6·5	Rapid fall checked suddenly.	Sudden veer from SW. to WSW.; continued to veer slowly to W. during next 1½ hour; hourly values decreased from 56 to 36 m. p. h.	...
Blackpool .	F. J. H. Coutts, M.D., for the Corporation.	10·2	Fall ceased; sudden rise ·03 in.	Sudden veer from WSW. to NW. by W.; squall 58 m. p. h., followed by temporary decrease of wind.	...
Bidston .	W. E. Plummer, F.R.A.S., for the Mersey Docks and Harbour Board.	10·9	Fall ceased; sudden rise ·02 in.	Sudden veer WSW. to W.; squall 80 m. p. h.	Shower ·01 in.
Manchester .	Prof. A. Schuster, F.R.S. .	11·3	Fall ceased; sudden rise ·04 in.	Sudden veer WSW. to N. by W.; squall 46 m. p. h.	...
Nottingham .	A. Brown, M.Inst.C.E., F.R.Met.Soc., for the Corporation.	12·5	Fall ceased; trace discontinuous, so that sudden rise is not shown.	Squall 44 m. p. h.	Shower ·10 in.; thunderstorm.
Yarmouth .	G. T. Watson, for the Meteorological Office.	14·3	Fall ceased; sudden rise ·05 in.	Sudden veer WSW. to NW. . . .	Thunderstorm, hail.
Plymouth .	H. V. Prigg, A.M.I.C.E., F.R.Met.Soc., for the Corporation.	14·3	Bar. minimum; then very irregular small changes.	Veered W. to NNW.; squall followed by decrease of wind.	...
Scilly . .	A. Hicks, for the Meteorological Office.	14·8	Fall ceased; no sudden rise.	Veered W. by N. to N. by W. in course of half an hour.	...
Oxshott .	W. H. Dines, F.R.S. .	15·0	Fall ceased; sudden rise ·06 in.	No squall; decrease to light airs . .	Thunderstorm, hail, snow.
Rousdon .	C. Grover, for the Hon. Lady Peek.	15·4	Fall ceased; no sudden rise.	Squall 48 m. p. h.	Shower ·10 in.; no thunder or hail.

occurred in connection with the squall varied generally between 0·1 and 0·2 inch; in the south-east the latter limit was slightly exceeded.

The most northerly places from which hail is reported are Gigglewick and Whitby in Yorkshire, and the most westerly one is Pembridge in Herefordshire. To the south and east respectively of these two places, hail and thunderstorms appear to have been very general, and in the Midlands and the south-east they appear to have been universal. I have not met with a single instance in the latter region in which an observer definitely states that these phenomena did not occur. Many instances of damage by lightning are reported from the Midlands, East Anglia, and Kent.

TABLE IV.—Anemogram Stations.

Station.	Observer.	Time of passage of Squall.	Wind and Remarks.
Deerness . .	M. Spence, for the Meteorological Office.	3·0	Sudden veer SW. to W.; gale, 37 m. p. h.; thunderstorm at Kirkwall, 3 to 4 a.m.
Armagh . .	J. L. E. Dreyer, Ph.D., for the Meteorological Office.	7·0	Commenced veer SW. to W.; change complete at 8 a.m.; shower.
Kingstown .	R. Gray, C.E., for H.M. Office of Works.	8 to 10	Gradual change WSW. to WNW.; gale.
Roche's Point .	Capt. Usborne, for the Harbour Commissioners.	9·8	Sudden increase from about 25 to 38 m. p. h.
Aspatria . .	J. S. Hill, B.Sc., F.R. Met. Soc.	8·7	Sudden veer from W. to NW.; snow squall; squall, followed by further increase.
Alnwick Castle	R. Kyle, for the Duke of Northumberland.	9·0	Sudden veer WSW. to W. by N.; hourly velocity decreased from 44 to 29 m. p. h.
North Shields .	Capt. T. Robson, for the Meteorological Office.	9·5	Sudden veer from WSW. to WNW.; hourly velocity decreased from 32 to 18 m. p. h.
Holyhead .	F. M. Cotton, C.E., for the Meteorological Office.	10·4	Sudden veer W. to WNW.; gale, 75 m. p. h., set in.
Fleetwood .	The Urban District Council, for the Meteorological Office.	10·3	Sudden veer from SW. to NW.; gale, 52 m.p.h., from NW.
Shoeburyness .	The Superintendent of Experiments.	14·8	Squall, 80 m. p. h., followed by drop to 10 m. p. h.

The hail and thunderstorms appear to have been confined to the region in which the change of wind was marked by a sudden increase of pressure, and in which the squall was succeeded by a marked lull in the wind force lasting for a considerable period.

The Distribution of Pressure.

I have tabulated a selection of the traces which I had at my disposal, and, with the help of the values of pressure and wind so obtained, I have constructed synchronous charts for the British Isles for every hour or every second hour of the period under review. M. Durand Gréville was,

TABLE V.—Barograms, with Time of Check of Fall and Amount of Sudden Rise.

Station.	Observer.	Fall checked.	Amount of Sudden Rise.	Remarks.
			in.	
Stornoway . .	J. Mackenzie, for the Meteorological Office.	0·5	...	...
Glencarron . .	D. D. Munro, for Lord MacLaren.	2·3	·03	...
Strathpeffer Spa .	H. W. Kay, M.B. .	3·0	·02	...
Lochabers . .	G. Muirhead . .	3·0	Zero	...
Clarinish . .	F. C. Buchanan . .	4·0	Zero	...
Rowe . . .	—— Barge . .	4·0	Zero	...
Thornton Hall (Lanarkshire).	A. H. Bishop . .	5·7	Zero	...
Forgandenny .	C. L. Wood . .	5·7	Zero	Rain 5·8
Malin Head .	Lloyd's Signalman, for Meteorological Office.	4·0	Zero	...
Rosbeg . .	J. M'Loone . .	4·7	Zero	...
Larne . . .	E. W. L. Holt, for Department of Agriculture.	6·5	Zero	...
Bangor (Co. Down)	J. S. McTear . .	7·0	Zero	...
Ardfry (Co. Galway).	W. M. Tattersall, for Department of Agriculture for Ireland.	7·6	·03	...
Streete (Co. Westmeath).	W. E. Wilson, F.R.S.	8·0	Zero	No thunder.
Ardgillan . .	Capt. E. R. Taylor, F.R.Met.Soc.	6·5?	Zero	No hail.
Dublin . .	Sir J. W. Moore, M.D., F.R.Met.Soc.	9 or 9·5	Zero	...
Kilkenny . .	H. Carlton, for the Marquis of Ormonde	9·0	Zero	...
Cronkbourne .	A. W. Moore, M.A., J.P., C.V.O.	8·7	Zero	...
Newcastle-on-Tyne	L. Richardson, M.A. .	...	·04	...
,, ,,	Messrs. Brady and Martin.	9·5	·05	Heavy squalls.
Rossall . .	T. G. Benn . .	10·3	·03	...
Giggleswick .	C. F. Mott, M.A. .	10·5	·03	Hail, strong wind.
Chester . .	Ll. S. Lloyd, M.A. .	11·0	·02	...
Penbedw . .	H. W. Buddicom .	?	·02	...
Huddersfield .	J. Woodhead . .	11·0	·02	Hail, thunderstorm, heavy squalls.
Leeds . . .	H. Crowther . .	10·0?	·05	Hail, thunderstorm, snow, strong wind.
York . . .	O. Grabham, M.A. .	11·2	·04	Driving rain, thunderstorm.
Sheffield . .	C. J. Barker . .	11·5	·03	...
Haverfordwest .	E. P. Phillips, F.R.Met.Soc.	11·5	Zero	...
Hesley Hall .	B. I. Whitaker, J.P., F.R.Met.Soc.	...	·01	Hail, rain, great darkness.
Cheadle (Staffs) .	J. C. Philips, J.P. .	12·3	·04	Thunderstorm, strong wind.
Fulbeck . .	Rev. Vere F. Willson, M.A.	12·6	·04	Thunderstorm.
Birmingham .	Prof. Poynting . .	12·7	·04	Thunderstorm.
Norwich . .	By Dr. H. R. Mill .	13·8	·06	Thunderstorm, hail, snow.
Cambridge . .	A. R. Hinks, for Meteorological Office.	13·8	·09	Thunderstorm, hail, snow.
Cardiff . .	By T. L. Ainsley .	14·0	·02	...

TABLE V.—Barograms, with Time of Check of Fall and Amount of Sudden Rise—*continued.*

Station.	Observer.	Fall checked.	Amount of Sudden Rise.	Remarks.
			in.	
Cirencester . .	Prof. P. G. Gundry, for Royal Agricultural College.	14·0	·01	Thunderstorm, hail.
Hitchin . .	F. Ransom . . .	14·5	·05	Thunderstorm.
Bristol . .	By Dr. H. R. Mill .	14·1	...	Fall of bar.; no recovery.
Tavistock . .	E. E. Glyde, F.R.Met. Soc.	14·7	Zero	Shower.
London:—				
Pall Mall . .	Athenæum Club . .	15·0	·07	Thunderstorm, hail, rain, snow.
Ealing . .	H. Newby, F.R.Met. Soc.	15·0	·07	,,
W. Kensington .	G. von U. Searle .	15·0	·07	,,
Cadogan Gardens	F. Druce, F.R.Met.Soc.	15·0	·06	,,
City . . .	J. E. Clark, F.R.Met. Soc.	15·0	·06	,,
Westminster .	The Staff, Meteorological Office.	15·0	·08	,,
East Horsley, Surrey	L. F. King-Noel .	15·0	·06	,,
Greenhithe . .	Capt. D.Wilson-Barker, F.R.Met.Soc.	...	·06	,,
Thames Ditton .	H. T. Potter . .	...	...	,,
Hastings . .	H. Colbourne, M.R.C.S., for the Corporation.	16·0	·04	Squall, hail, thunderstorm, increased dryness.

I believe, the first to point out that the correct manner of representing on synoptic charts the sudden increase of pressure shown by the barograms is by a "fault," or discontinuity, in the isobars; and in drawing the charts I have adopted this method of representation. With the large number of records at my disposal it would have been difficult to represent the facts in any other way; smooth isobars of the ordinary type would have involved the rejection of a large proportion of the observations. In all the maps I have endeavoured to make the size of the "fault" in each isobar represent the magnitude of the sudden increase of pressure.

TABLE VI.—Thermograph Stations.

Station.	Observer.	Time.	Remarks.
Crathes	J. Smith, F.R.Met.Soc.	5·0	Fall commenced.
Warlingham . . .	R. H. Curtis, F.R.Met.Soc.	15·1	Sudden fall, thunderstorm, hail.
Epsom	S. C. Russell, F.R.Met.Soc.	15·0	Thunderstorm, hail.

A selection of the charts is reproduced in Figs. 3 to 7. The synchronous chart for 6 p.m. on the previous evening (February 7) showed a high pressure system over the ocean to the south-westward of the British Isles, and a moderate gradient for South-westerly wind over the north of the country and Scandinavia. Shortly after 6 p.m. a rapid fall of

the barometer occurred in the north-west, with the result that the gradient soon became very steep. Figs. 3 and 7 show the distribution of pressure over north-western Europe at 8 a.m. and 6 p.m. on the 8th. The position of the line of squall has been marked on both charts by

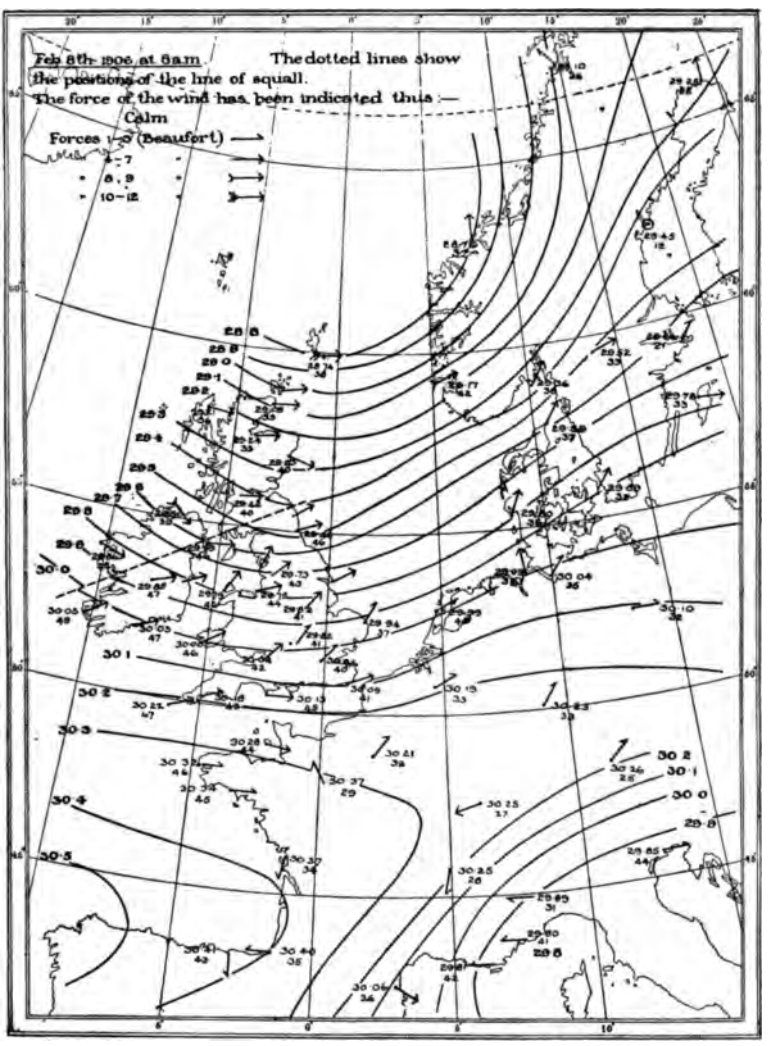
Feb 8th 1906 at 6 a.m.
The dotted lines show the positions of the line of squall.
The force of the wind has been indicated thus :—
Calm
Forces 1–5 (Beaufort)
" 6, 7
" 8, 9
" 10–12

FIG. 3.

a dotted line, which in both cases forms a line of separation between a region of South-westerly or West-south-westerly wind and one of Westerly or North-westerly wind. It has been suggested that lines of squall radiate from centres of cyclonic depressions round which they rotate like the spokes of a wheel. There is, however, no evidence for bringing the dotted lines shown in Figs. 3 and 7 into any special connec-

tion with a centre of low pressure, which we may suppose to have existed off the coasts of Norway and Scotland. It must be admitted that the wind directions recorded at 6 p.m. at Skudesnaes and Faerder (North-west and South-west respectively; see Fig. 7) suggest that a line of

FIG. 4. FIG. 6.

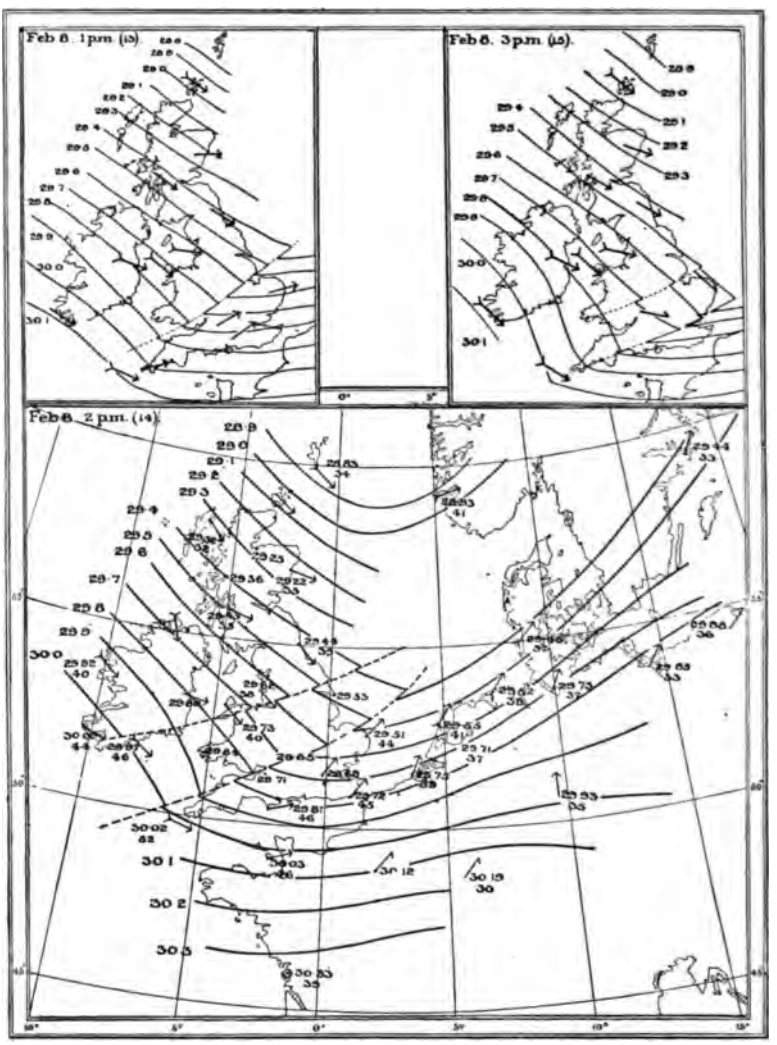

FIG. 5.

separation between a North-westerly and a South-westerly current extended at this hour from the neighbourhood of the minimum near Christiansund in a southerly direction; but there is no direct evidence for connecting this line with the one shown over France and the Netherlands. Had such a connection existed we should expect the line to have

advanced, and to have affected stations in the north of Germany; but the barogram from Hamburg published in the Daily Report of the Deutsche Seewarte betrays no sign of any sudden changes corresponding with the passage of a line of squall.

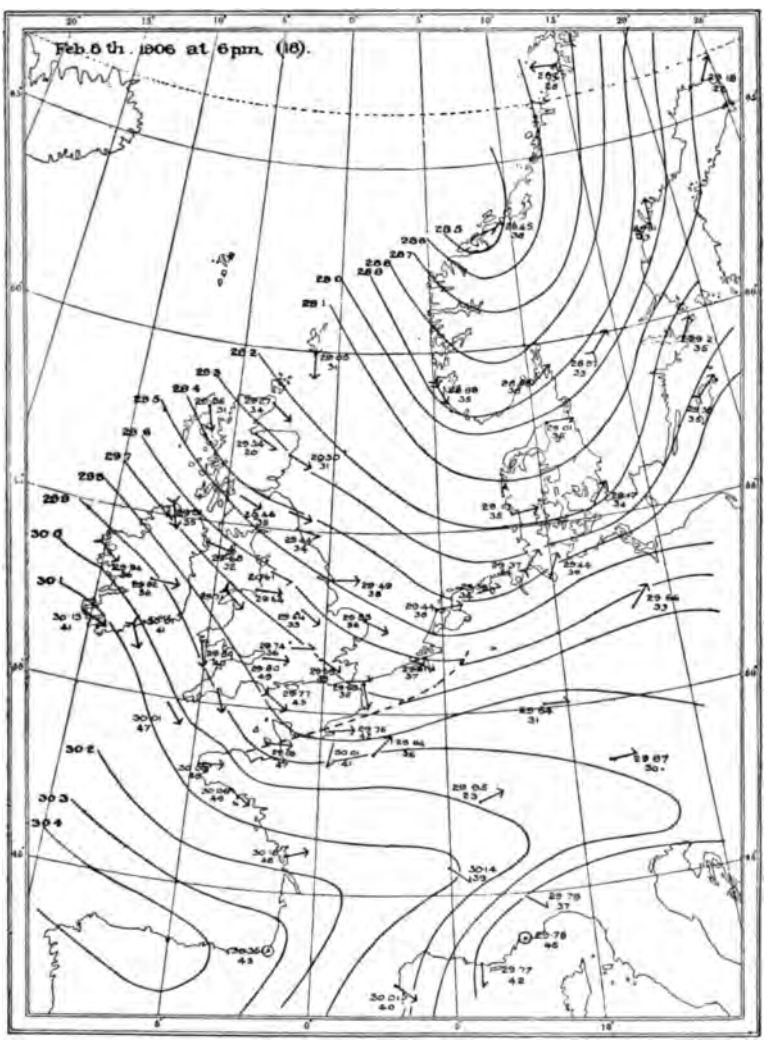

FIG. 7.

The distribution of pressure over the British Isles might be briefly described as being represented by two sets of parallel isobars, the one for West-south-westerly wind, the other for North-westerly wind. Over Scotland and Ireland the two sets of lines meet at a more or less well-defined angle, but there is, as a rule, no discontinuity at the points of junction. The sudden increase of pressure shown by the barograms from Glencarron and Strathpeffer Spa has been already referred to.

A similar isolated case of a sudden rise of the barometer occurred at Ardfry on the coast of Galway. In each of these cases the isobars have been drawn with "faults" in them. Over England, except in the south-western districts, "faults" were general; in the south-east their magnitude was but little less than the distance between consecutive isobars.

TABLE VII.—Stations contributing Notes.

Station.	Observer.	Time.	Remarks.
Inverness . . .	W. G. MacConnochie .	2-3 a.m.	Squall from NW.
Pembridge (Hereford) .	Rev. R. P. Danser .	12·7	Squall, hail, distant thunder; fall of temp. 47° to 39°; wind shifted to NW.
Coleford (Forest of Dean)	C. O. Hanson, for P. Baylis	13·5	Squall, hail.
Dunmow (Essex) . .	T. Hacking, for Countess of Warwick	14·7	Thunderstorm.
Portsmouth . . .	A. M. Fraser, M.D., for the Corporation	15·0	Thunderstorm, hail.
Bognor	A. G. Thompson, F.R.Met.Soc.	15·0	Thunderstorm, hail.
Swarraton . . .	Rev. W. L. W. Eyre, M.A., F.R.Met.Soc.	15·0	Heavy hail.
Tunbridge Wells . .	F. G. Smart, M.B., F.R. Met.Soc.	15·5-16	Thunderstorm, hail, rain
Whitby	T. Newbitt . . .	10·3	Squall, thunder, rain, hail.
Llangammarch Wells .	W. B. Jones, M.D. .	...	Nothing unusual in weather.

In the earlier maps the line of squall makes angles of considerable magnitude with both sets of isobars, but the considerable increase in its rate of propagation over the south-east of England has the effect of rendering it almost parallel to the isobars for South-westerly wind in the latest stages (see map for 6 p.m., Fig. 7). It would be interesting to determine whether this gradual approximation of the direction of the line of squall to the direction of the isobars has any connection with the persistency of the former.

Trajectories of the Air.

I have utilised the hourly synchronous charts in an attempt to determine the trajectories, or actual paths of the air over the surface of the earth, in a manner similar to that adopted in an investigation which I have recently undertaken with Dr. Shaw.[1] The results are shown in Figs. 8 and 9, while Table VIII. gives the pressure, velocity of motion, and, where possible, the temperature of the moving air for each hour.

In front of the line of squall the trajectories all move from south-west to north-east; the velocity of the air generally increases while its pressure decreases rapidly. The temperature, as a rule, shows a slight decrease, but the phenomena are in this case complicated by diurnal changes.

[1] *The Life-History of Surface Air Currents: a Study of the Surface Trajectories of Moving Air.* Published by Authority of the Meteorological Committee, M.O. 174.

In the rear of the line of squall the direction of motion of the trajectories was from north-west. In the west of the country (trajectories N and O) the velocity was great, and generally increasing slowly. In the case of P the air experienced a rapid decrease of velocity as it reached the midland and eastern counties. Again, if we try to trace the air in the North-westerly current over East Anglia *back* to its origin, by

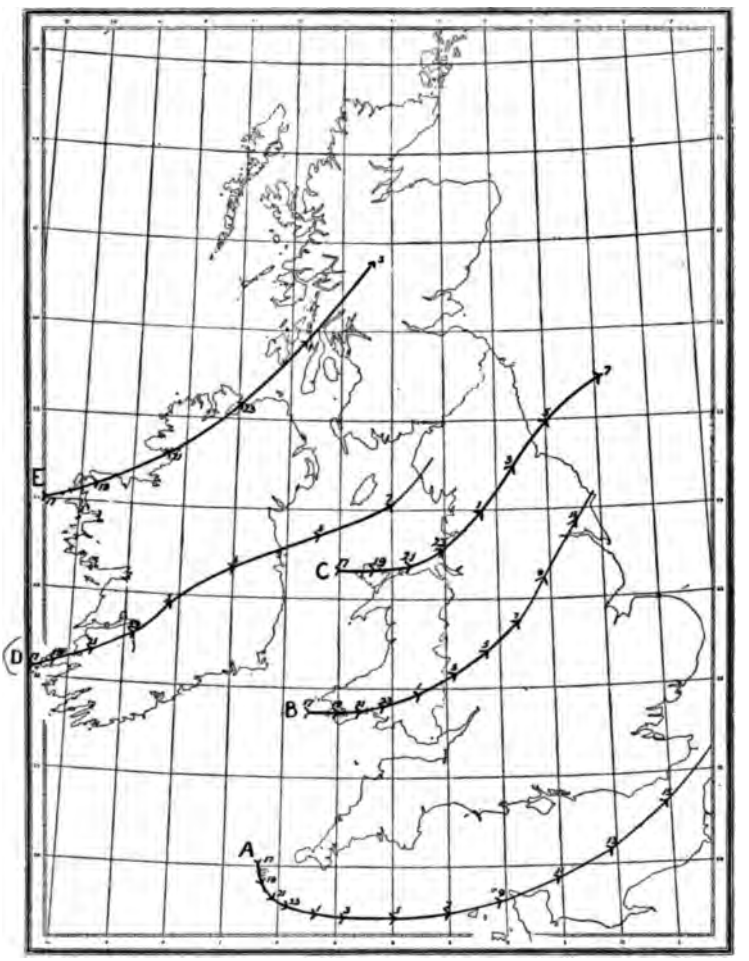

FIG. 8.—Trajectories of Air.

working the process of tracing trajectories backwards (trajectories R and Q), we soon find ourselves overwhelmed by the line of squall, *i.e.* the origin of the air must be sought in the upper regions of the atmosphere and not on the surface.

The changes of pressure along these trajectories were very different from those which occurred in front of the squall line. Whereas the motion in the latter case was taking place under rapidly diminishing

pressure, in the North-westerly current it occurred under practically constant pressure.

The line of squall was so persistent that it appeared of interest to determine the motion of the air with reference to it. The result is given in Fig. 10. The diagram was obtained from the diagrams of trajectories by compounding, according to the parallelogram law, a motion equal and

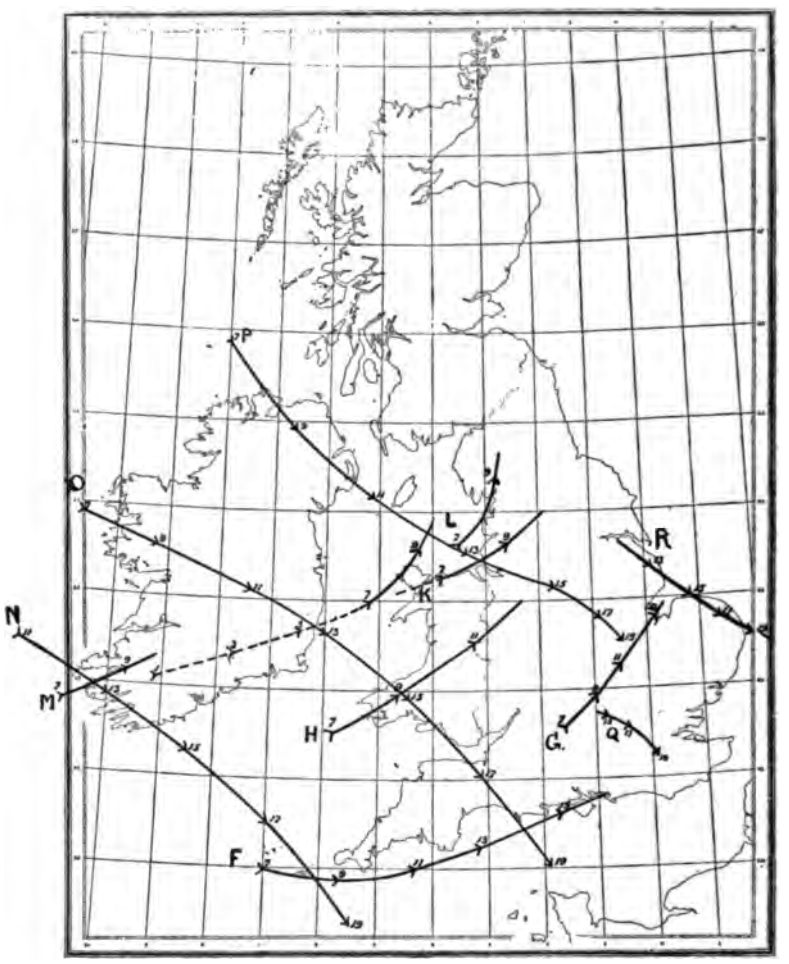

FIG. 9.—Trajectories of Air.

opposite to the motion of the line of squall with each step of the trajectories. Details of the method are given in *The Life-History of Surface Air Currents*, referred to above. The final result, as depicted in Fig. 10, represents the motion as it might appear to an observer travelling with the line of squall. In front of the latter the air is moving with great velocity to meet the squall line at an angle of about 45°. In its rear we must again distinguish between the western and eastern parts of the diagram. In the west the motion of the air was approximately the same

as the motion of the line of squall, and hence the relative motion of the one with regard to the other was small and irregular. In the east the air appeared to be moving away from the line of squall with a velocity which was still great, but considerably smaller than the velocity of approach on the southern side. The complete change in the character of the motion on the two sides of the line of squall points to the latter

TABLE VIII.—Showing the Variations in Velocity V, Pressure P, and Temperature T, of the Air in the Trajectories of Figs. 8 and 9.

Feb.	Hr.	Trajectory A.			Trajectory B.			Trajectory C.			Trajectory D.			Trajectory E.		
		V.	P.	T.	V.	P.	T.	V.	P.	T.	V.	P.	T.	V.	P.	T.
			ins.	°		ins.	°		ins.	°		ins.	°		ins.	°
7	18	9	30·48	47	10	30·41	44	16	30·36	43	12	30·45	47	21	30·30	...
	20	6	30·48	...	10	30·40	...	14	30·31	...	14	30·40	...	31	30·15	...
	22	8	30·48	...	10	30·36	...	17	30·24	...	16	30·33	...	35	30·05	...
	24	10	30·43	...	14	30·30	...	21	30·15	41	19	30·20	...	35	29·85	...
8	2	13	30·41	...	16	30·25	...	21	29·95	...	28	30·12	...	40	29·55	...
	4	20	30·39	...	16	30·13	...	22	29·74	...	35	29·95	...			
	6	21	30·29	...	18	29·98	...	29	29·55	...	32	29·80	...			
	8	21	30·24	44	20	29·82	41	...	...	...	32	29·60	44			
	10	24	30·15	...	24	29·60	...									
	12	24	30·04	...												
	14	27	29·85	45												
	16	27	29·65	...												
		Trajectory F.			Trajectory G.			Trajectory H.								
8	8	31	30·22	47	16	30·00	40	35	30·00	46						
	10	31	30·15	...	18	29·82	...	35	29·82	...						
	12	27	29·98	...	22	29·45	...	35	29·65	...						
	14	34	29·81	46												
		Trajectory N.			Trajectory O.			Trajectory P.			Trajectory Q.			Trajectory R.		
8	8	...	...	...	37	29·86	44	42	29·51	39						
	10	...	...	...	37	29·85	...	42	29·62	...						
	12	37	30·08	46	37	29·86	...	42	29·62	...						
	14	37	30·05	45	37	29·83	...	36	29·63	38	...	...	...	20	29·52	...
	16	45	30·03	...	45	29·82	...	20	29·63	...	10	29·68	...	15	29·52	35
	18	47	30·01	47	45	29·77	43	15	29·62	33	15	29·69	...	15	29·53	36

The hours are numbered consecutively from 1 to 24, commencing at 1 a.m.

The wind direction was from WSW. or SW. in trajectories A to H and from NW. in trajectories N to R.

being a region of discontinuity of motion, *i.e.* we are dealing with the motion of different air on the two sides of it.

The Secondary Squalls.

As is so frequently the case, the primary squall was succeeded by a number of secondary squalls, which in some cases attained considerable intensity. Table IX. gives the times at which the traces of the self-recording instruments show irregularities which may probably be accounted for by such causes.

The figures in the first column are plotted in Fig. 11. They afford fairly satisfactory evidence of the existence of a secondary "line-squall" which followed in the rear of the primary at an interval of about two hours. In the diagram the continuous lines numbered 11 to 18 show

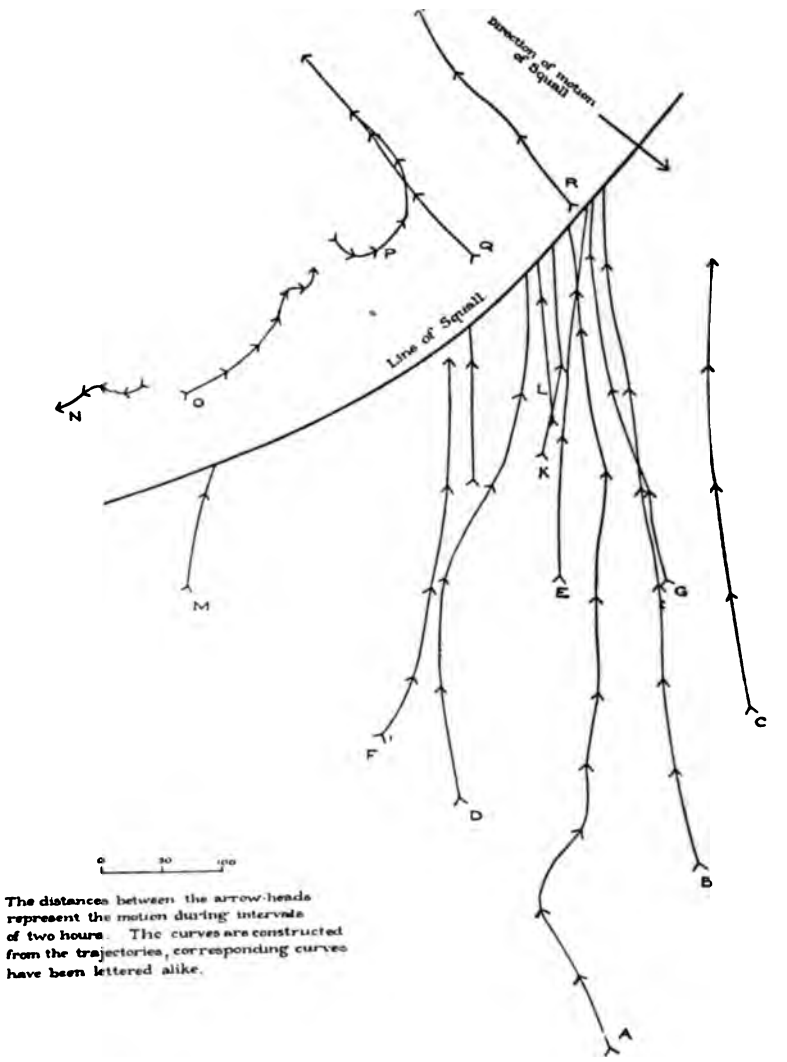

FIG. 10.—Motion of Air with reference to the Line of Squall.

the advance of this squall. At a number of stations in the Midlands the sudden increase of pressure caused by the passage of the squall was of considerable magnitude, and I have accordingly indicated it on the maps by a small "fault" in the isobars.

The figures in the second column (shown in brackets in Fig. 11) also probably hang together, but the evidence that they form the con-

tinuous series suggested by the dotted lines in the figure is less satisfactory; the fact that a well-equipped station like Southport should have been crossed by the line without any of the instruments being affected is rather disturbing.

TABLE IX.—Times of Occurrence of Secondary Squalls.

Stornoway	...	...	9·0
Clarinish	...	...	9·0
Paisley	...	11·0	...
Glasgow	...	11·3	...
Aberdeen	...	9·5	...
Forgandenny	...	10·8	...
Edinburgh	...	11·8	...
Bangor (Co. Down)	10·5	...	...
Armagh	10·9	...	...
Kingstown	12·5	...	...
Roches Point	14·5	...	12·1
Cronkbourne	...	...	20·3
Alnwick Castle	...	12·5	...
Aspatria	11·2	13·3	...
Newcastle	...	13·0	...
Giggleswick	13·0	...	16·0
Holyhead	13·3	16·5	11·5, 17·5, 18·3
Fleetwood (Rossall)	12·7, 13·0	15·5	18·8, 21·0
Blackpool	12·7	15·3	17·8, 18·3, 22·5, 23·8
Southport	13·3	...	11·5, 14·0, 16·7, 16·9, 18·2, 20·3, 22·8, 23·8
Stonyhurst	13·3	15·7	18·0
Manchester	14·0	16·5	12·3, 22·3, 26·5
Bidston	13·7	...	20·0, 22·0, 24·0
Chester	14·0	16·5	21·0
Penbedw	...	...	21·0
Leeds	13·6	...	...
Harrogate	14·0 ?	...	...
Scarborough	...	14·5	...
York	13·8	...	...
Sheffield	14·3	16·7	...
Hodsock	14·5	17·2	19·3, 22·0, 23·0
Chatsworth	14·1	17·7 ?	...
Nottingham	14·7	17·8	...
Cheadle	13·8	17·0 ?	...
Birmingham	15·3	...	...
Haverfordwest	14·5	...	...
Cardiff	...	18·0	...
Geldeston	15·9	...	...
Yarmouth	15·8	...	...
Hitchin	16·5	...	...
Berkhamsted	16·7	...	...
Oxford	16·5	18·7	...
Shoeburyness	17·8	...	...
Kew	17·1	19·3	...
Rousdon	18·1	...	...
Falmouth	18·3	...	19·7, 25·5
Scilly	18·0	...	...
Hastings	17·8 ?	...	...

The figures in the third column do not lend themselves to the tracing out of systems of isochronous lines. The phenomena appear to have been very complex and irregular.

Conclusion.

It is not my purpose to enter into a discussion of the nature of the changes taking place in the region of unstable equilibrium along the line of separation of the South-westerly and North-westerly air currents, but the traces of the self-recording instruments show some interesting points which are worth recording.

At Southport the veer of the wind commenced at 10.26 a.m., and was complete at 10.38 a.m.; the squall occurred at 10.38 a.m. The rapid rise of the barometer lasted from 10.36 to 10.39 a.m., and the period of heaviest rainfall from 10.26 to 10.39 a.m. The heavy rain and the veer of the wind thus commenced together; and the completion of the veer, the squall, the end of the rise of the barometer, and the slackening of the rainfall were also simultaneous phenomena. The time-scales of the instruments are very open, and the times of changing the sheets as determined from the traces agree well with those marked on the charts.

At Kew, where the phenomenon was more intense, the course of events appears to have been slightly different. The change of wind commenced at 2.49 p.m. and was complete at 2.52 p.m. The squall occurred at 2.53 p.m. The increase in pressure, which attained the

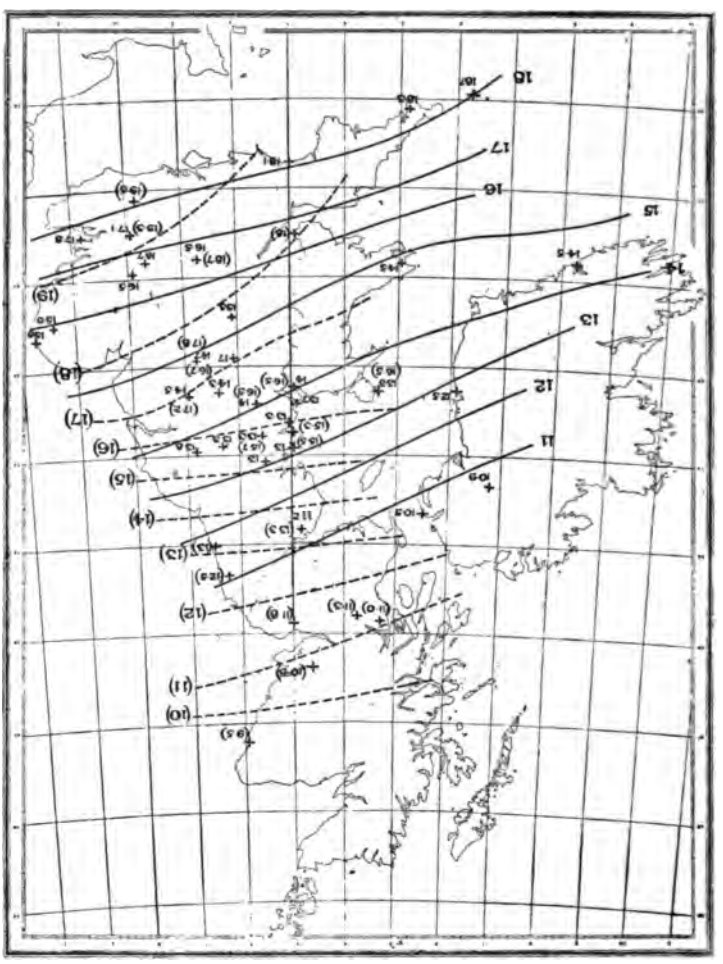

FIG. 11.—Times of Occurrence of Secondary Squalls and Isochronous Lines showing their advance.

[NOTE.—The continuous lines are based on the figures not enclosed in brackets; the dotted lines are those enclosed in brackets.]

magnitude of 0·09 in., lasted from 2.51 till 2.55 p.m.; the rapid fall of temperature commenced at 2.52 p.m. The anemograms are set by hand, and there may thus be an error of a minute or two in them, but it is justifiable to regard the squall, the completion of the veer of wind, and of the rise in the barometer as approximately simultaneous; but the rain commenced to fall heavily as early as 2.40 p.m., and by the time that the wind began to veer at 2.49 p.m. 7 of the 12 hundredths of an inch of pre-

cipitation associated with the passage of the squall had already fallen. (The record is unfortunately slightly blurred at its commencement; it ends exactly at 10.20 a.m. on the 9th, which was the time quoted as that of changing the sheets.)

This throwing forward of the rainfall as the storm became more intense suggests that some of the condensed water was carried forward by an upper North-westerly wind. Several correspondents mention the heavy black clouds which came up from the north-west in advance of the storm. I have received the following account from the Observatory at Cambridge:—"Thunder began at 1.40 p.m. Heavy darkness came up rapidly from north-west about 1.45. Very heavy thunder and lightning about 1.50; then hail, very big stones; lightning continued till about 2.25, one flash lavender, but this colour exceptional; hail turned to rain, and then to snow. Storm passed off to south."

The changes in the humidity of the air are also not without interest, as they afford some evidence that downward as well as upward convection currents occurred in the squall. In spite of the heavy rain and hail, the air became considerably drier after the squall than it was before it. At Kew the difference in temperature between the dry and wet bulb thermometers immediately before and after the squall remained constant, in spite of the fact that the temperature of the air was lowered by more than seven degrees. Elsewhere the changes were more striking. At Southport the humidity at the time of the squall fell immediately from 99 to 78 per cent, and later to 71 per cent, and a hygrogram from Hastings shows a similar but less pronounced change.

In this connection it is interesting to note that the two secondary squalls which reached Kew shortly after 5 p.m. and 7 p.m. respectively both gave rise to an increase and not a decrease of temperature (see Fig. 1). Neither of them was accompanied by measurable precipitation. A rise of temperature also occurred at Geldeston at the time of passage of the first of these "secondaries."

I do not wish to suggest that the ascent and descent of air are in any way comparable in amount. It is of course true that ascent of air must always be counterbalanced by corresponding descent, but the two regions may be separated by hundreds of miles or more. The very rapid upward convection on the line of squall, of which the heavy fall of rain or hail affords evidence, may be associated with a much more gradual descent in some altogether remote region. The phenomena presented by a line-squall may perhaps be compared to the advance of a wave of water over a flat shore. The air which is displaced upwards by the advancing water represents the warmer and therefore specifically lighter South-westerly wind, and the advancing wave itself the colder and denser North-westerly current. Within the advancing body of water some downward motion is taking place, but the horizontal motion is much more important than the vertical. The changes occurring along the line of discontinuity are probably very complex and the analogy not applicable.

Finally, it appears worth putting on record that two well-authenticated cases of globe lightning occurred during the storm. One of these has been described fully in the Society's *Quarterly Journal*.[1] The other

[1] "Lightning at Barsham, Suffolk, Feb. 8, 1906," *Quarterly Journal of the Royal Meteorological Society*, vol. xxxii. p. 170.

occurred at Haverhill in Suffolk. Mr. R. Ruffer has kindly supplied the following description of what was observed:—

A ball of fire as large as a cocanut, leaving a trail behind it, struck the mill about forty feet up and ran down the bell-wire and chain, melting the former and sending it on the white-washed wall like electro-plating. It set the links of the chain together, so that great force was required to separate them. I saw the fire-ball, about the size of a large orange, on the chain about forty feet up the mill, about one and a half yards off me. It stood still for a short time, and then went down to the bottom floor and exploded like a cannon when it came in contact with the ground. This happened about 2.20 p.m. on February 8. I was surprised to find after the explosion that very little damage had been done.

[The Discussion on this Paper will appear at the end of Mr. Brodie's Paper on "The Mean Prevalence of Thunderstorms."—EDITORS.]

Remarkable Display of Phosphorescence.

Mr. Douglas Carnegie, of 44 Shooter's Hill Road, Blackheath, has forwarded the following extract from a letter from his brother, Mr. A. A. Carnegie, an officer on board the ss. *Patrick Stewart*, giving an account of a remarkable display of phosphorescence which he observed in the Gulf of Oman:—

"This last voyage we witnessed a weird and most extraordinary electric phenomenon—I say 'electric,' for I cannot think of it being anything else. We were steaming along at eight knots in the Gulf of Oman. At 10.30 p.m. I was on watch, and noticed ahead of the ship a bank of apparently quiescent phosphorescence; it might have been a tide up or the sea lapping the beach, but I knew it could not with any degree of probability be the latter. Yet I kept a careful watch on it, as uncharted shoals and islands are ever out-cropping in these parts.

"When we got to within twenty yards of the whitish water I saw it break into life and light—shafts of brilliant light came sweeping across the ship's bow at a prodigious speed, which might be put down as anything between sixty and two hundred miles an hour. Then we steamed into the light, and the effect was weird to a degree. It was just as if a large gun with a rectangular muzzle were shooting bars of light at us from infinity. These light bars were about twenty feet apart and most regular; their brilliancy was dazzling. They first struck us on our broadside, and I noticed on our lee side that an intervening ship had no effect on the light beams; they started away from the lee side of the ship just as if they had travelled right through it.

"The direction from which the light bars came gradually veered round the whole compass. After a quarter of an hour of this harmless bombardment we ran into the night's ordinary darkness. But in another five minutes we were again attacked by the light bars, now travelling in a direction the exact opposite of the ship's course. This second attack lasted for about five minutes, and then the entertainment was over for the night. It was impossible to say whether the light bars travelled through the water or on its surface. I collected a bucketful of the water and examined it under the microscope, but could not detect anything abnormal. Altogether it was the most wonderful sight I have seen, and its inexplicability added to its weirdness and grandeur."

The phenomenon witnessed by Mr. A. A. Carnegie bears a close resemblance to the phosphorescent display observed by Mr. W. S. Hoseason, of the ss. *Kilwa* (see *Quarterly Journal*, vol. xxviii. p. 29).

NOTE ON A TYPICAL SQUALL AT OXSHOTT, MAY 25, 1906.

By WILLIAM HENRY DINES, B.A., F.R.S.

[Read June 20, 1906.]

THE sudden, though small, rise of barometric pressure which not unfrequently accompanies an ordinary summer shower is so difficult to explain that I have thought that the limited amount of information available in this particular case might be of interest, and perhaps throw some light on the changes that occur simultaneously at a few thousand feet elevation.

Squalls may roughly be divided into two classes—those in which a noticeable change of direction in the wind occurs (the V-depression squall), and those in which no change of direction is noticed. The squall at Oxshott on May 25 was of the latter kind.

Fig. 1 shows the trace from a microbarograph at Oxshott (*A*), the corresponding trace at Westminster (*B*), and the anemometer trace at Oxshott (*C*). Unfortunately there is no thermograph trace available. The direction of the wind was South-west throughout. It should be stated that the anemometer is very sheltered for South-west winds; were the exposure a good one, 50 or even more per cent would be added to the recorded velocities.

The traces show a steady wind of over 10 miles per hour until 11.0 a.m., then a distinct drop to less than 10 for some fifteen minutes, then a rise to over 20, accompanied by the usual sudden increase of barometric pressure, and in this case by a fall of a few hundredths of an inch of rain, which fell heavily but was of very brief duration. After the squall the wind dropped suddenly, and there was almost a dead calm for about twenty minutes.

There were shower cumulus clouds at 9 a.m., but by 10.30 the sky was almost clear.

The following information about the conditions prevailing up to 3500 ft. is available.

At 11.18 a.m. a kite flying on 4000 ft. of wire began to rise rapidly under a large advancing cloud; and at 11.19, although 500 ft. more wire had run out, the angular elevation had increased from 39° to 48°, and the vertical height from 2500 to 3500 ft. The ascent of the kite was certainly caused by an upward current, for the meteorograph shows during the time of its occurrence a steady wind velocity of about 25 miles per hour, and indicates no changes of velocity that could account for the rise. The squall commenced on the surface at 11.22, the estimated force on the Beaufort scale being 7, and at this time the kite was falling owing to a decrease in the velocity of the wind passing over it; by 11.23 the wind had almost failed at the kite, and the full power of the engine was being employed to haul it in and keep the wire off the ground. The effort was barely successful, since the wire fouled a small tree 300 yards distant, from which, however, it soon after broke away. At 11.26 the squall struck the kite, which was then at a height of 2400 ft., and three-quarters of a mile distant horizontally. Two minutes later

the velocity at the kite had risen to 58 miles per hour, and the wire broke under a strain of 180 lbs. and perhaps more. Three minutes later the kite fell at a spot 2¼ miles distant from Oxshott bearing N.E.½E.

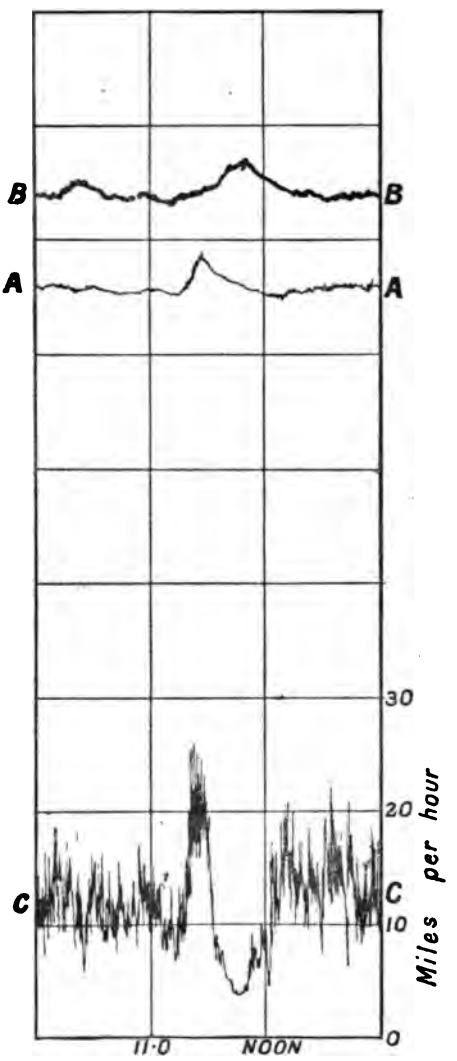

FIG. 1.

A. Microbarograph trace at Oxshott.
B. Do. „ Westminster.
C. Anemometer „ Oxshott.

So far as could be seen, the cloud-level was not reached; but fortunately the humidity trace at 11.19 is fairly distinct, and the rising current combined with the saturation value prove that the under surface of the cloud could not have been far distant. Possibly the cloud was reached, but the rain rendered the kite indistinct.

The figures obtained from the meteorograph are given below:—

Time.	Height above surface.	Temperature.	Relative Humidity.	Wind.	
				Velocity.	Direction.
a.m.	ft.	°	%	Miles per hour.	
10.45	0	59	80	13	S.W.
11.0	1200	46	?	25	S.W.
11.10	2500	43	60	25	S.W.
11.15	2250	44	80	25	S.W.
11.19	3500	37	100	25	S.W.
11.24	2400	38	100	15?	S.W.
11.25	2350	39	100	55	S.W.
11.29	0	46	?	?	

The humidity trace is not very distinct, and the values are somewhat doubtful.

It is probable that the squall did not extend as high as the cloud-level, for no disturbance in the uniform motion of the clouds was apparent.

It appears from the observational data that in this case there was a decided ascending current in front of the shower combined with the average horizontal velocity; four minutes behind this in time, or 2 miles in distance, if we assume that the disturbance travelled at a rate of 30 miles per hour, the approximate rate given by the two micro-barographs, there was a great decrease of velocity, combined possibly, but this is uncertain, with a descending current; again, two minutes or 1 mile behind this, a wind velocity of double the average. As the kite broke away, we cannot tell to what height the subsequent calm at the surface extended. The temperature conditions show a steep gradient in front of, and a small gradient behind, the shower.

The temperature decrease of 22° from the surface to 3500 ft. is beyond the adiabatic rate, but it must be remembered that the values 59° and 37° are not simultaneous. The decrease behind, namely 9°, is about the abiabatic increase that would occur in a falling mass of air and water particles mixed, provided that the evaporation from the water particles is sufficiently rapid to keep the air saturated. One can hardly suppose that the air is cooled by the sensible coldness of raindrops falling from a colder stratum, for the thermal capacity of the water contents in an ordinary shower is infinitesimal in comparison with that of the air through which the drops fall; but if the evaporating surface of the falling water is sufficiently large to keep the air saturated or nearly so, the cold produced by the evaporation will partly compensate for the adiabatic warming of a descending current, and thus a downward air current accompanied by rain may reach the earth as a cold current.

The average temperature gradient is 1° for 300 feet elevation. Roughly, the dynamic warming of descending air is 1° for 200 feet; hence, in general, descending air must be warm. Also, roughly, the dynamic warming of a mixture of descending air and evaporating water is 1° for 400 feet (for it is the exact converse of an ascending saturated current of air). In this case the warming is less than that which the average gradient supplies, and hence the air of the descending mixture is cold in comparison with its surroundings.

If, however, we may account thus for the fall of temperature, the characteristic rise of the barometer still remains to be explained. It is

true that the lower temperature of the air behind the shower increases the density, and in this particular instance the increased density is ample, considered statically, to produce the observed increase of pressure; but in a perfectly free and unconfined mass of gas such as the atmosphere, it is very hard to see why an increase of pressure does not immediately equalise itself by a flow of air to the surrounding districts. A pressure wave in air, produced by an explosion say, would travel at the rate of 12 miles per minute; the speed of a gravitational wave would not be very different, but the speeds of these waves shown on a microbarograph seldom exceed one-twentieth of this amount.

[The Discussion on this Paper will appear at the end of Mr. Brodie's Paper on "The Mean Prevalence of Thunderstorms."—EDITORS.]

Lightning Effects on Underground Mains.

The following letter came to hand too late for insertion in our "Correspondence" columns, from Mr. Arthur H. Shaw, chief electrical engineer to the Ilford Urban District Council:—

"The following occurrence, being very unusual, if not unprecedented, may be of interest to some of your readers.

"During the morning of Friday, the 17th inst., a heavy thunderstorm passed over Ilford, and two houses adjoining each other were struck by lightning. Both the houses were wired for electric light, and the lightning, in addition to going to earth through the water pipes, and fusing the taps, etc., struck the electric light fittings, fusing and tearing down the fittings.

"At the same time a serious fault developed on the mains, and it was found later that the insulation of the mains in the neighbourhood of the houses in question had failed in several places, certain house service boxes being burnt out, and a considerable length of distributor being entirely destroyed. At the same time the insulation of the mains at a point some 1200 yds. distant from the houses failed, and fittings in a shop 900 yds. distant, and at a station 1000 yds. distant from the houses, were fused and cut down. None of these fittings were switched on at the time, and the main fuses were only destroyed in one case.

"The system of mains is three-wire with neutral earthed at the station, the cables being lead-covered and laid solid.

"As this is the first time I have heard of an underground system of mains being interfered with by lightning, I should be glad to know if any of your readers have experienced a similar occurrence."

The circumstances appear to be unique. It would be interesting to know whether any effects were observed on the neutral wire at the generating station, whether the mains near the houses in question were concentric, and, if not, which were the mains that were damaged.—*Electrical Review*, August 31, 1906.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 16, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

ALLAN GORDON RUSSELL CAMERON, M.B., Town Hall, Worthing;
EDMUND WILLIAM STACEY JONES, Picton House, Carmarthen;
HARENDRA KRISHNA MUKHERJI, M.A., Calcutta, India;
CAPT. RAYMOND PARCOU, Victoria, Seychelles;
CAPT. WILLIAM HENRY ROTHWELL, Bombay, India; and
LAWRENCE CHARLES HILLS YOUNG, Bombay, India,
were balloted for and elected Fellows of the Society.

The following communications were read :—

1. "AN INSTRUMENT FOR TESTING AND ADJUSTING THE CAMPBELL-STOKES SUNSHINE RECORDER." By Dr. W. N. SHAW, F.R.S., and G. C. SIMPSON, F.R.Met.Soc. (p. 249).

2. "THE DEVELOPMENT AND PROGRESS OF THE LINE-SQUALL OF FEBRUARY 8, 1906." By R. G. K. LEMPFERT, M.A., F.R.Met.Soc. (p. 259).

June 20, 1906.

Ordinary Meeting.

RICHARD BENTLEY, F.S.A., President, in the Chair.

ERNEST GRAY COUTTS, Bombay, India;
HENRY THOMAS JACKMAN, Hong-Kong;
TIRUPATUR SREENIVASA SAMA ROW, Madras, India; and
FREDERICK WYON SIMMS, Dunedin, New Zealand,
were balloted for and elected Fellows of the Society.

The following communications were read :—

1. "THE MEAN PREVALENCE OF THUNDERSTORMS IN VARIOUS PARTS OF THE BRITISH ISLANDS DURING 25 YEARS, 1881-1905." By FREDERICK J. BRODIE, F.R.Met.Soc. [This Paper will be printed in a subsequent No. of the *Quarterly Journal*.]

2. "NOTE ON A TYPICAL SQUALL AT OXSHOTT, MAY 25, 1906." BY W. H. DINES, F.R.S. (p. 281).

CORRESPONDENCE AND NOTES.

Lectures on Meteorology.

During the last few months Mr. William Marriott has given Lectures on Meteorological subjects, in connection with the Society's scheme for diffusing a knowledge of Meteorology, at the following places :—

May 3.—Cirencester, Bingham Public Library.
July 10 and 11.—Royal Horticultural Society. Great Summer Flower-Show at Holland Park, Kensington.

The following letter has been sent to the Secretaries of the various local Scientific Societies, Public Schools, Educational Committees, etc., and also to the Fellows of this Society :—

70 VICTORIA STREET, WESTMINSTER, S.W.,
July 1906.

DEAR SIR,—The Council of the Royal Meteorological Society, with the view of advancing the general knowledge of Meteorology, promoting an intelligent public interest in the science, and making the work of the Society more widely known, last year appointed a Lecturer to act in co-operation with Scientific Societies, Institutions, and Public Schools in various parts of the country.

The success attending the project was so marked as to lead the Council to continue the appointment for another year.

We desire to call your attention to the opportunity which is thus presented of stimulating and directing in a scientific channel the popular interest always shown in the weather, and of obtaining authoritative information on matters regarding which the public are not always well informed.

The Lecturer, Mr. WILLIAM MARRIOTT, F.R.Met.Soc., is prepared to deliver Lectures on the following Meteorological subjects :—

1. "A CHAT ABOUT THE WEATHER."
2. "WEATHER FORECASTING."
3. "RAIN, SNOW, HAIL, AND THUNDERSTORMS."
4. "THE UPPER REGIONS OF THE ATMOSPHERE."
5. "CLOUDS, FOG, AND SUNSHINE."
6. "CLIMATE AND HEALTH."
7. "METEOROLOGY IN RELATION TO AGRICULTURE."
8. "HOW TO OBSERVE THE WEATHER" (ELEMENTARY).

The Lectures will be illustrated by Lantern Slides.

The Society possesses a valuable collection of photographs, drawings, diagrams, and charts, illustrating meteorological phenomena, and also various patterns of instruments used for meteorological observations. The Council are willing to make arrangements for exhibiting selections of these, under the charge of a member of the Staff, at gatherings of local Scientific Societies, or on other occasions when they are likely to prove of interest.

Particulars as to the Fees for the Lectures, and as to the terms on which the Exhibits can be lent, may be obtained from the Assistant Secretary, Royal Meteorological Society, 70 Victoria Street, Westminster, S.W., to whom all communications should be addressed.—We are, yours faithfully,

FRANCIS CAMPBELL BAYARD,
HUGH ROBERT MILL, } *Secretaries.*

Meteorology at the Royal Horticultural Society's Great Show, 1906.

The Royal Horticultural Society decided this year to include a Meteorological Exhibition in their Great Summer Show at Holland House, Kensington, July 10 and 11, 1906. The Royal Meteorological Society was invited to undertake the arrangements for this new departure.

The Exhibition, which was arranged in a large tent, contained an interesting collection of instruments and models, as well as photographs, maps, diagrams, and charts, illustrating meteorological phenomena. In the grounds adjoining the tent there was an enclosure with the requisite instruments in position for the equipment of a Climatological Station.

Mr. W. Marriott gave a short Address each day at 3.30 p.m. on "Meteorology in Relation to Gardening."

Repairing a Thermometer.

I think that the following facts should be known, as they reflect great credit on Messrs. Negretti and Zambra and on their excellent staff:—

Some two months ago a minimum thermometer mounted in a glass shield, which I had bought of them in January 1904, was struck by a tennis ball and broken as shown in the enclosed sketch in the line AB. The break was

perfectly clean, and without any very pronounced jagged edges, and the outer glass tube was not cracked at all. I took it to Messrs. Negretti and Zambra and asked them whether it could not be repaired, and they told me perfectly honestly that they did not think so; because when it was heated to be joined it would probably fly, and also, if repaired, the thermometer would in all probability be three or four degrees out. However, on my urging it they consented to try; and the repairing was so successful that they sent it to be reverified at Kew, with the result that the thermometer is more accurate than it was originally, while the cost to myself was slightly less than one half that of a new thermometer. I may add that the work has been so well done that I can myself only distinguish the join by a very slight crack in the enamel on the tube.

I append the two Kew Certificates for the thermometer.

November 1903.		June 1906.	
at 12°	−0°1	at 12°	−0°1
22	−0·2	22	−0·1
32	−0·3	32	−0·2
42	−0·3	42	−0·1
52	−0·2	52	−0·0
62	−0·2	62	−0·0
72	−0·3	72	−0·0

FRANCIS CAMPBELL BAYARD, *July* 11, 1906.

The Green Flash.

The momentary duration of the Green Flash is to be further explained as follows:—

The duration of the visionary image produced by looking at a bright coloured object depends on several conditions; as, for example, the condition of the atmosphere, the condition and direction of the eye of the observer, the time the object is looked at.

When the eye is in a condition of complete repose, and therefore susceptible, as in the evening twilight, or on waking in the morning, it will, if a bright-coloured object is looked at for a moment, produce out of itself a visionary image of this object in the complementary colour. This visionary image will itself last only a second or so, and may well be described as a "Flash."

There are some beds of Calceolarias in the flower-garden under my bedroom window. On getting up in the morning and opening the shutters I can hardly help looking on one or the other of these beds. My eyes after sleep being thoroughly rested, and therefore susceptible, a momentary glance is sufficient to stimulate them to produce the compensatory blue image, which at once becomes visible as a blue spot on the turf near the flowers.

This compensatory image is also momentary, lasting about a second, and then disappearing. It is best described as a "Blue Flash."

To apply this explanation to the case of the "Green Flash," seen at sunrise and sunset, the moment the red edge or red colour of the sun appears above the horizon at sunrise, or is just about to sink below it at sunset, the eye, if rested, and susceptible, should at once be impressed by it, and instantaneously produce a visionary image of it in the complementary colour. This visionary image will also be momentary, and may well be called a "Green Flash."

With respect to the second objection raised by Capt. Alfred Carpenter against the explanation of the Green Flash which I suggested, I doubt whether the Green Flash is ever seen unless the red edge of the sun, or the red colour announcing the rising of the sun, has first been seen above the horizon.—R. C. CANN LIPPINCOTT.

The Meteorological Office "At Home."

On Friday, July 6, Dr. W. N. Shaw, F.R.S., the Director, held an "At Home" at the Meteorological Office, which was attended by a large number of scientists interested in meteorological work.

The visitors had an opportunity of inspecting the Exhibit which the Meteorological Office had organised for sending out to the forthcoming International Exhibition at Christchurch, New Zealand.

The collection is intended to illustrate the methods of organisation adopted by the Meteorological Office and the institutions associated with it, and to represent the results obtained from the official stations, or by co-operation with volunteer observers, on land and on sea, of the United Kingdom, the Colonies, and other countries.

The Director considers that the most complete representation of the work accomplished by the Office is that presented by the list of publications which have been issued, but as this form of representation is not suited for a public exhibition, a selection of charts, diagrams, etc., has been made from those published, and has been included with specimens of the instruments used, the working forms adopted, and other illustrations of the method of organisation arranged according to the branches into which the staff of the Office is divided.

Lightning Statistics for Germany.

It appears to be the practice for statistics to be officially collected every year in regard to the cases recorded of damage caused by lightning in Prussia. The figures relate to what are termed (1) "kindling strikes," or cases where lightning causes fire, and (2) to "cold strikes," or instances where damage is done without producing a fire. The following table is a summary of the most recent statistics in respect of the first class of strikes:—

Year.	Total Number of Kindling Strikes.	Number in Towns.	Number in Country Districts.
1885 . . .	1327	155	1172
1887 . . .	766	137	629
1888 . . .	936	—	—
1895 . . .	1620	221	1399
1900 . . .	1434	—	—
1902 . . .	824	—	—
1903 . . .	813	—	—

In 1889, and in each of the years to 1893 inclusive, the number of the more dangerous class of strikes exceeded 1000. The maximum number was reached in 1895 with 1620, as shown in the table, when the damage, taken in conjunction with the 213 "cold strikes" in that year, represented no less than £325,600. This sum is, however, slightly less than the £328,450 damages caused in 1900 by the 1434 kindling and the 639 cold strikes which took place in that year. The greater portion of the destruction of property happened in

country districts, although the adoption of lightning conductors in recent years is said to be also affording the country localities a larger measure of protection. —*Electrical Review*, August 24, 1906.

Curious Advertisement of Instruments, 1797.

The following curious old advertisement card of a Derby tradesman will no doubt be read with interest :—

TO THE PUBLIC.

WEATHER GLASSES, &c. &c. made and repair'd as uſual, in the very beſt manner, in the BAG-LANE, DERBY,

Where your old ſervant STENSON dwells,
Glaſſes that ſhew you Heat or Cold he ſells ;
Likewiſe Hydrometers, they're very handy,
And truly ſhew what Water's in your Brandy.
If for a Weather-Glaſs you are inclin'd,
A better Maker you will ſeldom find :
Or old Barometers that don't go right,
He'll make them true, and pleaſing to the ſight,
At ſmall expence, he'll take them twenty miles,
Whether the road's by turnpike-gates or ſtiles.—
He's been the Public's ſervant nineteen years,
And means to be ſo until Death appears.

Capital Angle Barometers 2l. 2s. to 3l. 3s.—Neat upright ditto 1l. 10s. to 2l. 7s. Plain ditto, 10s. to 1l. 1s.———Fahrenheit's Thermometers, Spirits 6s. to 10s.—Mercurial 8s. to 1l. 1s.—Saccharometers, very uſeful to public and private houſes in aſcertaining the quantity of ſaccharine matter extracted in Brewing ; the beſt teſt yet known for trying the goodneſs of malt, and the only one for knowing the true value of Worts, Oil of Vitriol, or any fluid heavier than water.———Spirit Levels.——And a few capital Electrical Piſtols, &c.

July 10th, 1797.

Variation of the Nile Flood.

Capt. H. G. Lyons has recently published an elaborate and valuable work on *The Physiography of the River Nile and its Basin.* The following is his summary of the variations of the Nile flood :—

When the Nile floods are examined for a period of about 175 years, during which the records have all the appearance of being comparable and reliable, no regular alternation of high and low floods is to be found.

Turning to the meteorological conditions, atmospheric pressure in north-eastern Africa appears to vary inversely as the rainfall of Abyssinia, and a similar relation between pressure and rainfall has been demonstrated in other parts of the globe. The distribution of pressure in the summer months, in the light of recent information, shows that the Asiatic low pressure in the monsoon season is abruptly terminated about the meridian of the Nile valley, and to the west of this there is probably an area of almost equal pressure intervening between it and the high pressure of the Azores action-centre, while in summer a low-pressure area may lie to the south-west. The encroachment of this high pressure on the eastern part of North Africa may produce there the unfavourable conditions of high pressure which have been recognised as coinciding with deficient rainfall on the Abyssinian tableland ; while conversely its with-

drawal, so as to allow of deepening or extension of the low-pressure trough, probably acts favourably towards the conditions of precipitation in Abyssinia.

It seems that the two principal factors to be considered are firstly the strength of the South-east trade winds as they progress from the south to the north of the equator, along the eastern coast of Africa; and secondly, the excess or defect of atmospheric pressure in the area represented by Aden, Cairo, Beirut, and the region lying to the west of this: the subequatorial rainfall in early summer must also be considered.

So far as our knowledge goes at present it may be said that—

1. Generally speaking, the curve of Nile floods varies inversely as the mean barometric pressure of the summer months, high pressures accompany low floods, and low pressures accompany high floods.

2. These pressure variations show a great similarity over wide areas, but seem to be to some extent dependent upon the position of the Azores high-pressure "action-centre."

3. Taking the monthly means of atmospheric pressure, this relation is even more clearly shown, and pressure above or below the normal in months of the rainy season of Abyssinia coincides closely with deficiency or excess of rainfall.

4. Taking the 37 years—1869-1905—in 6 years out of 7 a very fairly accurate prediction of the flood from month to month could have been made, and there seems a reasonable probability that further and more detailed study of the conditions above described may increase the reliability.

5. The effect of excessive subequatorial rainfall in April and May in the neighbourhood of Zanzibar seems to have a distinctly prejudicial effect on Abyssinian rains.

Condensation from South-east Clouds on Table Mountain.

We alluded a year or two ago (*Geog. J.* 24, p. 96) to experiments carried out on Table Mountain by Dr. Marloth, with a view to ascertaining the amount of water supply which might be due to the condensation of the moisture from the South-east clouds on the surface of vegetation, as distinct from the actual fall of rain. The figures obtained were so large as to induce a doubt as to the trustworthiness of the results, it being pointed out that an isolated group of reeds, such as were used by Dr. Marloth, might capture a large amount of moisture, but that in the case of a more extended covering of vegetation the outer row of plants might screen those behind and impede their action.

Further experiments have, therefore, since been made, and are described by Dr. Marloth in the *Transactions of the South African Philosophical Society* (vol. xvi. 1905, part ii.). Several gauges with reeds were employed, one being placed in the open as before, while others were placed in the midst of closely growing bushes or reeds. The results proved that, while a considerable screening effect is exercised by the outer rows of bushes, especially during short periods of cloudiness, the quantity which did reach the sheltered gauges during longer periods of South-east clouds was far in excess of the total rainfall for the corresponding period. It is not, however, correct to assume that the difference between the records of a gauge with reeds and one without is wholly due to condensation by the reeds, for it was ascertained that during rain the gauge with reeds collects much more water than the ordinary one, but that the most pronounced difference occurs during misty rain, which shows how effective vegetation is, as compared with bare ground, in capturing moisture apart from real rain. Dr. Marloth endeavours to show by calculations that the amount of moisture available in the South-east clouds must be far more than many miles of reeds could ever capture, the soaking effect of these clouds being exceptionally great as compared with those from other quarters.—*Geographical Journal.*

Cloud Banners.

Every one who has lived among mountains has seen the clouds formed by the currents of moist air moving up the slopes. Sometimes the strong wind prevails only near the very top of a mountain, in which case the cloud forms a hood or cap, closely fitting and hiding the mountain top. At other times we have at the top a strong wind without enough moisture to form a cap cloud, a cape, or a tablecloth, as it is sometimes called; but nevertheless, close to the leeward of the mountain top, there is a small special region of slightly lower pressure, sometimes known as a region of discontinuity, analogous in many respects to the region immediately behind a pier in the strong current of a river. Into this region the air flows from all sides, producing a mass of whirls, analogous to the eddies behind a river pier, and, as it expands into this region, it expands just enough to form a slight cloud or haze, which floats like a flag or banner to leeward of the mountain top. The appearance, like smoke or steam, is apt to deceive a careless observer, for the whole phenomenon is simply a cloud, analogous to some forms of cirri. When the mountain top is covered with snow the drifting particles caught within this region of discontinuity also produce the appearance of steam or smoke, but it is simply drifted snow. A careful record of these cloud banners would add considerably to our knowledge of local climatology, since we so rarely can have observers stationed on mountain summits.

We are indebted to Mr. G. N. Salisbury, Section Director, Seattle, Washington, for a few observations on the banners of Mount Rainier, and we hope that many more may be recorded. He states that on March 6, 1906:

"The mountain was visible and entirely clear when I left my home on the hills at 7.15 a.m. About 8.30 a.m. the captain of the small excursion steamer *Acme* on Lake Washington, adjacent to this city, telephoned to me that there was apparently a heavy column of smoke or steam ascending from the peak of Mount Rainier, and that a large number of people were watching it from the shore of the lake. . . . It could be plainly seen from the State University, where it was observed by Professor Henry Landes, of the Chair of Geology, who declared it to be merely a good specimen of a cloud banner, due to a warm South wind blowing over the peak. Professor Landes has made several ascents of the mountain, and is well versed in mountain lore.

"The phenomenon has been observed several times before. . . . A similar appearance was noticed in December 1894, and caused some remark. The Post Intelligencer sent an expedition to the mountain at that time, but of course they could not get to the top at that season, only to the 9000-foot level. It was determined that the phenomenon noticed then was caused by masses of snow being carried by violent South-west winds across the lip of the crater, giving the appearance of masses of smoke, as the snow was broken into fine particles.

"There are, however, steam caverns in the crater, from the crevices of which a warm mist ascends in summer, as has been experienced by parties who have ascended the mountain and slept in the crater."—*Monthly Weather Review*, April 1906.

Circulation of the Upper Layers of the Atmosphere above the Maximum of the North Atlantic. By H. H. Hildebrandsson. [Translated by Dr. R. H. Scott, F.R.S., from the *Meteorologische Zeitschrift. Hann-Band*, 1906, pp. 117-120.]

It was Halley who was the first to show *a priori* the Counter Trades. These aerial masses brought by the two Trade Winds cannot accumulate incessantly in the region of the Equatorial Calms, so they rise and must divide themselves into two return currents which run in different courses in the upper regions of the atmosphere.

The existence of these return currents, or Return Trades, has been known for a long time. We have observed that in the Antilles enormous quantities of ashes coming from great volcanic eruptions have darkened the sky in the regions situated to the eastward of the volcanoes in eruption. Thus at the eruption of Morne Garou, at St. Vincent, on May 1, 1812, ashes fell on Barbados; and at the eruption of Conseguina, near the Lake of Nicaragua, on January 20, 1835, they fell in Jamaica.

We can also observe directly the return current at the Peak of Teneriffe, 3675 metres [12,057 ft.] in height, and on the crest of the volcano Mouna Loa in the island of Hawai in the Pacific Ocean.

In the different theories on the general circulation of the atmosphere it is admitted that the Counter Trades descend below the zones of calms at latitudes 30°, and continue their course at the ground level towards the Polar Regions [Dove and Maury]; or that the air which rises in the neighbourhood of the Equator moves as an upper current towards the environs of the Polar Circle, and returns as a lower polar current towards the Equator [Ferrel and James Thomson].

The observations of clouds carried out at a great number of stations distributed over very different latitudes have permitted us to determine in a great measure the general circulation of the atmosphere with complete independence of hypothesis or theory.

We have proved that above the thermal equator an Easterly current exists during the whole year. The existence of this current was observed after the eruption of Krakatoa in August 1883. The optical phenomena, caused by the volcanic dust, driven to the most elevated parts of the atmosphere, made the circuit of the globe in 12 to 13 days from east to west, that is to say, with a velocity of 37 metres per second [83 miles per hour].

Since the time of Humboldt it has been well known that the vapours and smoke which rise from the volcano Cotopaxi, situated close to the Equator, direct themselves constantly to the west. The height of the summit is 5400 metres [17,700 ft.], and the smoke column rises 2000 metres [6500 ft.] above that.

Above the Trades there exists a Counter Trade, but this Counter Trade does not pass beyond the polar limit of the Trade; it is deviated more and more to the right in the Northern Hemisphere, and to the left in the Southern Hemisphere, to become a Westerly current below the crest of the barometric maximum of the tropics, where it descends to join the Trade Wind.

The regions situated on the equatorial border of the Trade enter at times into the Trades and at others into the Equatorial Calms; below these there is consequently an upper monsoon: the Counter Trade in winter, and the Equatorial Current from the East in summer.

The air of the temperate zones is carried into a vast polar circulation, turning from west to east. The air of the lower strata approaches the centre, and that of the upper regions is drawn away more and more with height up to the highest regions of which we have observations. These layers of air above the temperate zones extend above the high pressures of the tropics to descend there.

The knowledge of the mean directions of the upper currents above the high pressure of the tropics is therefore of the greatest importance for our knowledge of the general circulation of the atmosphere. We have endeavoured to give on the two maps (Figs. 1 and 2, p. 294) the mean directions of the upper clouds above the barometric maximum of the North Atlantic in as complete a manner as possible. Since 1903 the observations from those regions have been largely increased. On the one hand, Mr. Bigelow has published a large number of observations from the Antilles; and on the other, Mons. Chaves, Director of the Meteorological Service of the Azores, has sent us the cloud observations of Horta, the Isle of

Fayal, since June 1902. Finally, we have calculated the means of the cloud observations published by Captain Toynbee in 1876 for the squares 38, 39, 40, 234, 301, 302, and 303.

It is true that all these means are calculated from a number of observations which is decidedly small, and in consequence of this the exactitude of each is not very great. But we think it useful to publish the results as a first approximation. In fact, the directions of the upper currents over the region in question seem to come out very well in these general features on the accompanying charts.

Above the Equatorial Calms the great upper current from the East is very well indicated. Above the Cape Verde Islands it comes from the South-east, to become later on the South-west Counter Trade over the meridional slopes of the barometric maximum. It is more and more deviated to the right, and above the crest of the maximum it blows from the West. Above the northern slopes there is an upper current from the West, in general with a component from the North.

Further towards the south, in the square 301, where is situated the island of Ascension, the mean direction of the current is from the North-east, and it is probable that further south it becomes the North-west Counter Trade over the North Atlantic Ocean.

It is evident that the study of the movements of the clouds gives us only an approximate knowledge of the movement of the upper currents of the atmosphere. To obtain results we must make detailed observations by using kites and balloons. Mr. Rotch was hardly able to cause a kite to fly from a steamer, as I had proposed to him in 1901 to make such observations over the North Atlantic Ocean. The route proposed by me is shown by the dotted lines on Fig. 1. Owing to the considerable cost, he has not been able to carry out this scheme.

However, in 1904 and 1905 it has been in part realised by the expeditions made by His Highness the Prince of Monaco, accompanied by Dr. Hergesell and by Messrs. Teisserenc de Bort and Rotch.

The experiments made from the Prince of Monaco's yacht, *Princess Alice*, have been carried out in 1904 in the triangle Oporto, Teneriffe, and Azores, and in 1905 along the route Gibraltar, Sargasso Sea, and Azores.

The expedition of Messrs. Teisserenc de Bort and Rotch, with their assistants Messrs. Maurice and Clayton, in July and August 1905 has passed by Teneriffe and Cape Verde up to 11° N. 30° W., to return by Teneriffe, Madeira, and the Azores. During all these expeditions they have used kites and balloons. The trajectory of the balloons of the Franco-American expedition has been exactly determined by triangulation by the two observers at the Azores, Madeira, Teneriffe, and the Cape Verde Islands. On other occasions a balloon has been sent up at sea and followed by the ship, although with less accuracy.

Thus the *Princess Alice* expedition has worked in the central region of the barometric maximum. In fact, it has hardly passed beyond the isobar of 764 mm. on Fig. 1. These three layers of air have been found superposed as usual in the interior of an anticyclone. The lowest had a velocity of 7 metres per second [16 miles per hour] from the North-east; it is the Trades. In that stratum the adiabatic 1° C. per 100 metres is always obtained, and its thickness is very slight—only from 100 to 600 metres [330 to 1970 ft.] Above that there is a sudden change. The temperature rises suddenly, and the humidity diminishes. This stratum has a thickness of about 1000 metres [3300 ft.]. The direction of the wind changes quickly from North to North-west, and its force diminishes considerably. The study of high pressure at the Trappes Observatory has proved that at most times there exists such a zone of light winds at a certain height above the ground. Above that layer there is another layer with a gradient exactly adiabatic, and the relative humidity increases with the height,

notwithstanding that the hygrometric richness remains constant. This points to the conclusion of a descending current. Dr. Hergesell calls that zone the layer of the Return Trade. However, the direction of the layer is not from South-west, but from the West with a component of North. In 1905 india-

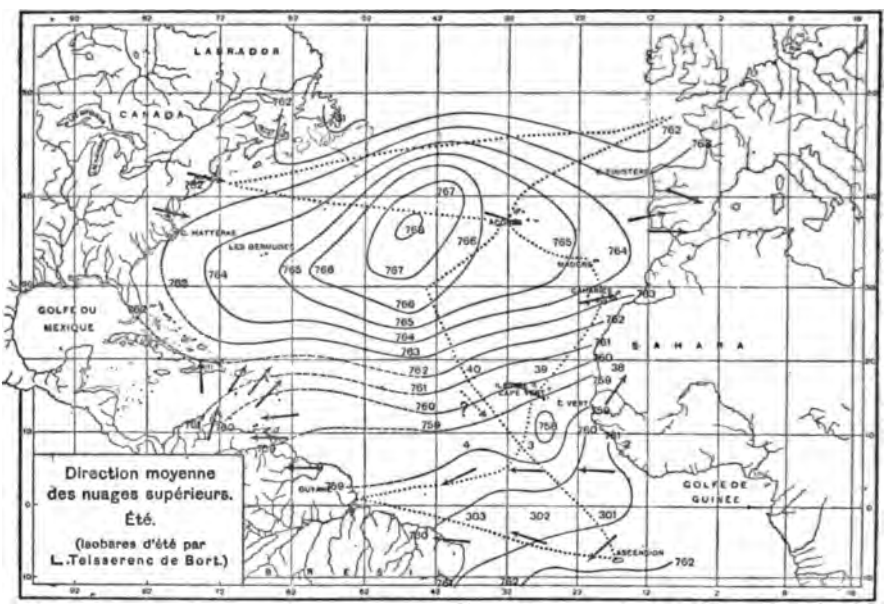

FIG. 1.—Summer.

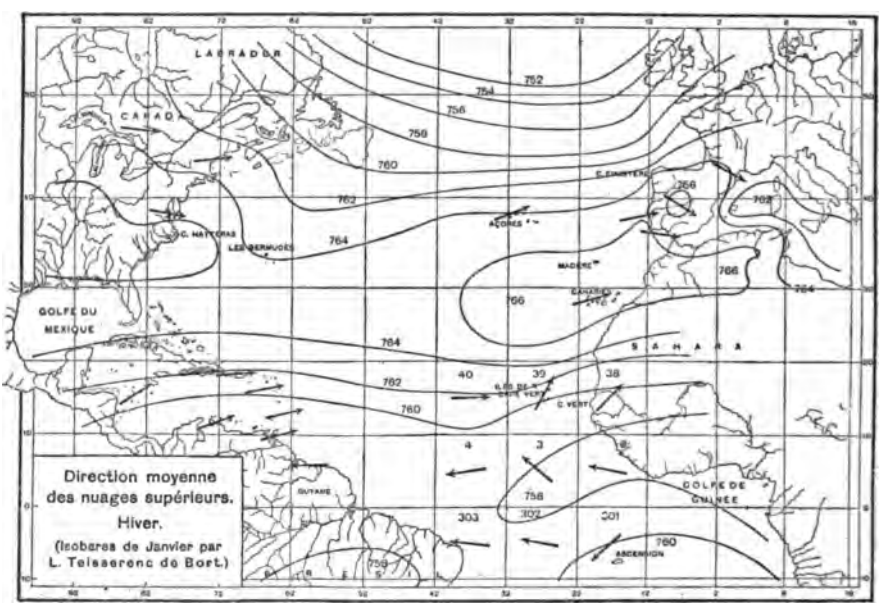

FIG. 2.—Winter.

rubber balloons had been sent up to a height of 10,000 metres [33,000 ft.] without encountering a Counter Trade from the South-west.

It is therefore proved that the Return Trade from the South-west does not reach to the crest of the barometric maximum; it is deviated to the right and becomes a descending current, very light from the West, as we have shown from cloud observations. To the north of the centre the high pressure is supplied by an upper wind from the North-west coming from the great polar circulation.

But Dr. Hergesell goes too far when he says: "Many statements have brought me to the belief that these South-west winds observed on the Peak of Teneriffe by several observers are of local origin and due to the island." That is abundantly proved by the observations made by Messrs. Clayton and Maurice during the expedition of Messrs. Rotch and Teisserenc de Bort in 1905.

They have found the following results:—

1. The winds which go towards the Equator are from North-east to East in the low regions, and generally from North-west to North-east above 1000 metres [3300 ft.].

2. To the north of Madeira and towards the Azores the upper winds, as we know already from the cloud observations, are generally from West and North-west, that region being ordinarily to the north of the oceanic barometric maximum, and outside the zone of the Trades.

3. The currents returning from the Equator, or the Counter Trades, transfer themselves by winds with South components generally, South-west in the latitude of the Canaries, South-east towards the Cape Verdes, thus proving the influence of the earth's rotation. The Counter Trades, such as have been admitted by meteorologists, exist therefore in reality.

At the most southerly point, 11° N. 30° W., we find at 2500 metres [8200 ft.] above the North-east Trade the strong East winds bringing the alto-cumulus. We are therefore at the northern limit of the upper East winds prevailing above the thermal equator.

In comparing these results with the mean directions of the upper clouds in summer, Fig. 1, we find a perfect agreement. These charts may therefore serve as a preliminary guide to future expeditions. A great part of the programme proposed by us in 1901 has been carried out, but there remains the route between Cape Verde, Guiana, and Ascension. But it will be evidently useful to go further southward to find the Counter Trade from the North-west over the Southern Atlantic, the mean direction at Ascension being still from the North-east; that is to say, that island has the same situation at the south of the Equator as the Cape Verde Islands to the north.

Evidently a course from Boston to Bermuda, the Antilles, and Guiana would be of the greatest interest.

Experiments in winter would be of the greatest importance. The South-west Anti-Trade is much more steady and strong in winter than in summer; which is often the case in the Antilles, according to Mr. Bigelow.

This would prove that the tropical maximum is fed in summer mostly from the North, which would bring great masses of air from the warmest hemisphere to the coldest.

Thus our results concerning the general circulation of the atmosphere are verified by direct observations made by means of kites and balloons.

Beech Trees and Lightning.

The popular belief that beech trees are never struck by lightning would seem to be now exploded. Six men were sheltering under a beech tree in the Midlands during last week's severe storm; two were killed, and the others struck down insensible. At the inquest, the coroner said he had specially

examined the tree, as for years he had read and understood that there was no record of a beech tree being struck by lightning. In this case the lightning had not injured the tree to the extent of damaging a leaf, but it was an accepted fact that six men were sheltering under a beech, and that two of them were killed whilst they stood there. He did not know whether there was anything in it or not, but it appeared to him to be a remarkable circumstance after what he had understood for so long, and he should record the fact that it was a beech tree in the verdict.—*Electrical Review, August* 10, 1906.

Rainfall of Durban, Natal.

Mr. R. Fermor Rendell, of the Government Observatory, Natal, has sent us the following table of rainfall at Durban, Natal. From 1871 to 1883 the records are from the Botanical Gardens, and from 1884 to 1905 from the Government Observatory :—

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1871	2·71	3·59	...	8·77	2·15	·11	·59	2·60	1·07	...	...	...	...
1872	...	1·67	4·33	17·10	2·33	3·00	4·65	·65	5·40	4·17	11·19	5·70	
1873	4·80	2·93	8·93	2·06	·62	...	·94	2·42	2·64	3·61	6·37	7·01	42·33
1874	7·17	4·24	9·12	3·74	1·17	2·66	·49	1·40	1·54	1·86	7·85	13·82	55·06
1875	3·64	3·80	6·06	2·11	·22	2·05	5·57	·27	5·56	3·35	16·62	5·53	54·78
1876	5·37	6·40	2·48	4·17	·30	2·03	·94	1·25	4·45	1·70	3·84	2·29	35·22
1877	5·18	8·09	1·94	2·31	·04	·90	1·16	·87	2·12	6·89	3·29	2·88	35·67
1878	2·67	5·05	2·72	2·11	3·34	1·89	·24	·32	·14	1·31	4·80	3·65	28·24
1879	6·37	3·27	7·17	·71	2·41	1·35	2·55	4·37	3·61	4·11	5·04	3·50	44·46
1880	7·02	7·12	2·98	4·55	3·20	·82	...	·99	·89	5·20	8·70	6·16	47·63
1881	7·07	3·44	1·91	·82	·29	·69	·68	7·48	3·07	1·86	6·23	3·53	37·07
1882	4·08	2·05	2·26	3·15	2·29	·22	2·43	2·12	2·12	4·30	2·68	6·90	34·60
1883	4·48	4·12	10·87	1·53	2·20	·28	·06	4·21	·70	7·65	4·10	4·32	44·52
1884	4·08	5·01	5·16	·50	1·02	2·69	·16	·51	3·26	12·19	8·40	1·58	44·56
1885	4·77	2·32	2·91	2·22	1·00	·26	·03	·61	10·43	2·75	3·15	4·03	34·48
1886	3·04	6·55	3·05	4·00	2·18	...	3·13	·50	·86	·55	4·79	3·14	31·79
1887	4·28	3·54	3·55	3·41	4·26	·74	·80	3·76	1·35	1·41	3·05	1·72	31·87
1888	5·19	5·05	5·45	2·18	3·91	·50	·85	1·15	4·40	4·10	1·34	3·62	37·74
1889	8·36	4·97	2·01	1·49	2·42	·23	·17	1·26	1·10	4·06	1·95	1·52	29·54
1890	1·93	4·79	2·01	8·00	·51	·30	·10	·64	1·09	5·31	3·55	4·68	32·91
1891	4·54	4·21	11·01	·64	3·20	·91	2·60	1·87	·84	4·16	4·03	7·44	45·45
1892	1·10	7·50	1·34	·91	1·28	...	·43	3·39	5·58	5·85	6·51	4·48	38·37
1893	6·94	6·77	6·54	4·29	3·88	·10	1·74	·81	13·84	13·65	8·33	4·38	71·27
1894	1·72	3·64	2·19	4·20	2·94	·58	·32	·38	10·06	3·68	2·85	4·71	37·27
1895	5·70	10·17	11·10	4·47	1·29	·08	·75	·55	1·63	2·60	1·93	11·23	51·50
1896	2·95	3·80	4·28	5·34	1·00	·11	·71	1·34	3·89	5·31	4·34	6·56	39·63
1897	3·87	1·48	5·82	1·13	·30	3·80	·02	·90	4·71	4·82	2·95	4·59	34·39
1898	4·49	5·62	2·76	4·79	2·75	·47	·24	2·09	2·00	6·02	5·55	5·70	42·48
1899	5·69	1·35	4·15	1·49	1·59	·17	·49	·23	1·68	6·28	2·01	3·62	28·75
1900	3·91	2·57	2·14	1·55	·38	1·04	1·62	1·56	1·37	4·52	3·74	2·84	27·24
1901	5·93	3·56	9·04	6·56	2·13	2·80	·02	3·17	7·07	3·20	8·17	3·89	55·54
1902	6·35	2·09	10·23	2·52	1·21	·73	·27	3·90	2·54	2·23	5·15	3·96	41·18
1903	2·44	2·40	4·13	5·97	·91	·70	1·16	1·85	·62	1·16	8·99	5·33	35·66
1904	4·11	8·77	4·87	·65	·44	·66	1·89	·18	·58	2·52	3·61	6·44	34·72
1905	4·44	5·48	4·07	·89	·81	11·12	·71	1·29	2·39	3·87	6·87	3·01	44·95
Mean, 21 Yrs., 1884-1904 inc.	4·35	4·58	4·94	3·16	1·84	·80	·83	1·46	3·76	4·59	4·49	4·54	39·34

The records for the years 1871 and 1872 are incomplete.

Rainfall at Pretoria.

Mr. R. T. A. Innes in his *Annual Report* of the Transvaal Meteorological Department for 1905 gives a series of tables of rainfall data collected in

previous years. The daily rainfall as measured by Mr. J. L. Soutter at the Government Buildings, Pretoria, is printed *in extenso*. The monthly results are as follow :—

RAINFALL.

MONTHS.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January .	3·58	11·81	11·03	4·46	1·37	5·78	11·20	5·45	7·03	4·83	4·22	3·13	3·96	1·92
February .	4·60	8·81	4·49	3·02	7·73	3·10	1·09	1·56	2·97	1·37	4·18	2·44	5·45	3·29
March . .	2·69	2·06	2·66	3·78	2·29	3·50	1·87	2·38	3·58	6·32	3·25	2·45	7·40	4·94
April . .	·88	·87	1·09	·32	1·51	·33	·35	·75	1·18	1·74	1·70	4·82	·38	1·51
May . .	1·09	·00	1·93	·25	1·16	·53	·21	·48	·00	·01	·27	·33	·10	·74
June . .	·00	·20	·08	·00	·95	·00	·00	·06	·55	·07	·01	·00	·07	·00
July . .	·00	·47	·00	·00	·00	·00	·00	·08	·15	·01	·03	·00	·00	·00
August . .	·00	·11	·41	·00	·35	·26	·23	·01	·10	·45	·02	·00	·02	·16
September	1·34	3·70	1·20	·10	·79	·13	·53	1·77	·00	1·34	·33	·21	·34	·34
October .	3·38	1·72	2·90	·33	1·06	2·53	·76	2·06	·87	4·54	2·65	1·25	·23	1·15
November.	1·20	6·69	2·98	2·36	1·80	2·70	4·75	2·64	7·49	6·27	2·80	5·53	5·86	...
December .	3·81	3·07	8·36	6·11	3·62	7·48	2·28	3·65	3·10	2·66	5·78	4·07	2·70	...
Year . .	22·57	39·51	37·13	20·73	22·63	26·34	23·27	20·89	27·02	29·61	25·24	24·23	26·51	...

DAYS OF RAIN.

MONTHS.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
January .	10	19	16	18	5	14	16	19	13	12	14	15	10	14
February .	11	10	13	12	13	11	8	5	9	6	14	9	13	11
March . .	...	11	12	8	10	8	12	14	11	20	9	10	14	9
April . .	...	2	7	6	8	5	5	5	6	6	5	11	5	6
May . .	...	0	4	3	6	2	4	3	0	1	2	5	1	3
June . .	0	1	1	0	3	0	0	2	3	3	1	0	1	0
July . .	0	3	0	0	0	0	0	3	3	1	1	0	0	0
August . .	0	2	4	0	4	1	1	1	2	2	1	0	1	1
September	2	6	5	1	4	3	2	3	0	5	2	2	1	2
October .	...	10	7	4	7	14	3	7	7	11	7	5	4	4
November.	...	16	13	15	9	8	11	11	13	11	12	13	12	...
December .	...	15	19	16	17	16	13	13	13	13	18	12	13	...
Year . .	...	95	101	83	86	82	75	86	80	91	86	82	75	...

Meteorological Observations at Bulawayo.

The Rev. E. Goetz, S.J., has recently contributed a paper to the Rhodesia Scientific Association on the Meteorological Observations at Bulawayo. The observations were taken at St. George's School, by the Rev. Fathers Barthelemy and Nicot, S.J. They were commenced in 1887; but in June 1903 the meteorological station was transferred to the Observatory in the suburbs. As the distance is very short and the altitude the same within a few feet, the observations taken in the new station were used to complete the means for the eight years 1897-1905, which are given in the accompanying table.

Bulawayo is in 28° 40′ longitude E., and 20° 9′ latitude S. The approximate altitude is 4469 ft. above sea-level.

Months.	Temperature.						Relative Humidity at 9 a.m.	Amount of Cloud at 9 a.m.[1]	Rain.[2]	
	Means.				Extremes.				Amount.	No. of Days.
	Min.	Max.	Range	Mean.	Min.	Max.				
	°	°	°	°	°	°	%		in.	
January	61·8	83·5	21·7	72·6	54·0	96·5	72	6·2	5·27	16
February	60·1	80·9	20·8	70·5	49·0	95·0	69	5·7	2·24	9
March	60·0	81·0	21·0	70·5	50·0	94·3	65	3·4	2·51	11
April	55·9	79·7	23·8	67·8	42·5	92·0	63	3·0	·73	5
May	49·8	74·4	24·6	62·1	37·4	92·0	52	2·3	·25	2
June	45·2	69·7	24·5	57·5	33·0	81·0	57	2·8	·07	2
July	44·8	71·7	26·9	58·3	36·0	88·0	51	1·3	·00	0
August	48·2	76·2	28·0	62·2	36·5	92·0	47	1·2	·09	1
September	53·8	82·1	28·3	67·9	32·8	97·4	44	0·7	·15	1
October	59·7	87·6	27·9	73·7	37·0	102·0	44	1·9	·80	5
November	61·3	85·5	24·2	73·4	51·8	105·0	57	5·6	4·77	12
December	61·0	81·6	20·6	71·3	52·0	93·5	66	5·2	5·32	12
Year	55·1	79·5	24·4	67·3	32·8	105·0	57	3·3	22·20	76

[1] Means of 3 completed years, 1898-99-1900.
[2] Means of Rainfall are for the 8 years starting July 1897 and ending July 1905.

RECENT PUBLICATIONS.

British Rainfall, 1905. *On the Distribution of Rain in Space and Time over the British Isles during the year* 1905, *as recorded by more than* 4000 *observers in Great Britain and Ireland, and discussed with Articles upon various branches of Rainfall work.* By HUGH ROBERT MILL. London, 1906. 8vo. 10 + 271 pp.

The volume in Part I. contains:—(1) A Report to the Observers; (2) Original Articles, dealing with a remarkable publication of rainfall data in Germany, and with the relation of Evaporation to other meteorological phenomena; (3) Tables of the amount of evaporation at 11 stations, of the duration of rainfall at 8 stations, and of the complete daily observations of rainfall at 10 stations; (4) An account of the staff of Observers and of changes in the stations at work, together with a map showing those parts of the country where new Observers are most urgently wanted; and (5) an Obituary list.

In Part II. the conditions of 1905 are exhaustively treated as to (6) Observers' Notes on the rainfall and weather; (7) Heavy Falls of Rain, their distribution over the country, and their relation to atmospheric disturbances, with several maps; (8) The distribution of Rainfall in Time, including the number of rain days classified according to amount of fall, droughts, and rain spells; (9) The monthly and annual rainfall in relation to the average; and (10) The General Table, giving the names of all Observers or responsible authorities, particulars as to position and exposure of the rain gauges, the total annual rainfall, and the number of rain days.

Dr. Mill has given a number of maps showing the distribution of rainfall on special occasions, and these add greatly to the value of the work.

Climatological Atlas of India. Published by the authority of the Government of India under the direction of SIR JOHN ELIOT, K.C.I.E., F.R.S., late Meteorological Reporter to the Government of India and Director General of Indian Observatories. Issued by the Indian Meteorological Department, 1906. Folio, 32 pp. and 120 plates.

This Climatological Atlas of India has been prepared to show all the more important features of the climatology of that tropical area, as determined from the results of the observations recorded during the first 25 years of the operations of the Imperial Meteorological Department, initiated in the year 1875-76. The average values used in the preparation of the Atlas were published in vol. xxii. of the *Indian Meteorological Memoirs.*

The Introduction contains a brief history of the progress of the work of meteorological observation in India, and also of the growth of the Meteorological Department, a list of the observatories contributing observations that have been utilised in the preparation of the Atlas, with their position and elevation, and a brief explanation of the charts.

The first 6 maps are of a general character, showing the orographical features and the various political and meteorological divisions of India.

Plates 7-10 show the isobars and winds for January and July over Southern Asia and the Indian Ocean.

Plates 11-23 each contains three maps, showing for each month and for the year the distribution of atmospheric pressure, and also the direction and force of the wind. The large map is for 8 a.m.: and the two small maps are for 10 a.m. and 4 p.m., *i.e.* the times of the daily maximum and minimum values.

Plates 24-36 each contain three maps for each month and for the year: the large one showing the mean pressure and the wind for the day, and the small ones showing (*a*) the actual diurnal range, and (*b*) the diurnal range reduced to sea-level pressure.

On Plates 37-49 the large chart shows the mean daily temperature, and the two small ones the mean maximum and the mean minimum temperatures for each month and for the year. Similarly the charts on Plates 50-62 show the mean diurnal range of temperature, and also the absolute maximum and minimum temperatures.

Plates 63-75 show the distribution of relative humidity in each month and on the mean of the year, the large chart giving the mean for the day and the small ones the values at 8 a.m. and 4 p.m. respectively.

In a similar way, Plates 76-88 show the corresponding distribution of aqueous vapour pressure, and Plates 89-101 the mean cloud distribution.

Plates 102-120 show the distribution of rainfall and the number of rainy days in each month and for the year, and also for the two seasons, and the four subordinate seasons. The small maps on these plates also show the storm tracks for each month.

All the maps in the Atlas have been admirably prepared, and they are all coloured in such a way as to bring out the salient features in a prominent manner.

Sir John Eliot says that a *Handbook of the Meteorology of India* is in course of preparation, which will give a full statement of all the more important features of the climates and weather of India.

First Report of the Meteorological Committee to the Lords Commissioners of His Majesty's Treasury, for the Year ended March 31, 1906. Presented to both Houses of Parliament by Command of His Majesty. London, 1906. 8vo. 154 pp.

The Meteorological Council having been dissolved on March 31, 1905, the administration of the Parliamentary Grant and the general control of the Office was taken over by the new Meteorological Committee, which is constituted as follows :—Dr. W. N. Shaw, F.R.S. (Director), chairman, Capt. A. M. Field, F.R.S., Capt. A. J. G. Chalmers, Dr. W. Somerville, Sir G. H. Darwin, F.R.S., Prof. A. Schuster, F.R.S., and Mr. G. L. Barstow.

The present Report contains the official correspondence relating to the constitution of the Meteorological Committee, and also an account of the changes which have been effected in the Office and of the work done.

The Appendices give full details of the data received by the Meteorological Office, and of the information which is supplied to the public. The reports on the inspection of the stations, and the list of books and pamphlets received in the library, however, are not given in this Report.

Popular Meteorological Handbook. Some Facts about the Weather. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary, Royal Meteorological Society. London 1906. 8vo. 32 pp.

This cheap little handbook has been written to convey in a popular form most of the leading facts about the weather which apply to the British Isles. The subjects dealt with are : Weather Sayings, Meteorology, Climate and Weather, Instruments, Temperature, Atmospheric Pressure, Wind, Moisture, Cloud, Rain, Snow, Hail, Lightning, Thunderstorms, Sunshine, The Upper Air, Weather Changes, and Vegetation.

The work contains numerous maps, charts, and illustrations of meteorological phenomena.

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